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From Challenge to Balance: The Transition from Traditional to Sustainable Economics

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From Challenge to Balance

The Transition from Traditional to Sustainable Economics

by

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Abstract

The subject of this master thesis is the concept of a circular economy as a sustainable economic model, and how it fits traditional economics developed in the 19th century. The subject is discussed with a nuanced and holistic approach from an economics perspective, attempting to describe why a sustainable economic model is necessary, and how a successful transition may find place. The thesis is meant as a contribution to the existing research on the field.

The traditional linear economic model is still the dominating model today. It has been the foundation for substantial wealth-creation over the last centuries, however it seems to fail in incorporating environmental concerns. The thesis explores how rethinking and reconstructing our economic models from the linear approach to a circular economy can in fact maintain value creation and economic growth, while minimizing the climate footprint left on our planet. The circular economy bears the potential to increase the duration and quality of goods and services produced as well as reduce residual waste, by incorporating the environment and planetary boundaries as constraints. The earth is a closed loop system with limited resources and resilience, and our economic models and behavior should reflect this.

Google Scholar is utilized to establish a foundation of existing literature on circular economy and supplements with relevant theory on welfare economics and network effects. Economic theory dictates that scarce resources are to be utilized at full capacity, maximizing the output from these scarce resources. However, the established linear economic model proves the opposite. Resources are not utilized to their full potential, accommodating for collective mass production and over-consumption. The thesis proposes how identifying categorical barriers obstructing the transition to a circular economy and strategically use the quantified barriers as a tool in policy-setting, can in fact initiate a constructive transition toward a circular economy. Theory on welfare economics and network effects are utilized to illustrate how deflating the barriers through legislation can enable the market forces to stabilize the market in a circular economy, by establishing strategic incentives to induce the successful transition toward the sustainable economic model – the circular economy.

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1 Introduction and Fundament for Thesis

For decades environmental concerns have been on the agenda for politicians, policymakers, and the public. Initiatives have been taken and progress have been made, but we are still faced with new challenges to further mitigate our environmental footprint. As the interest of sustainability and the interlinked issues of environment and development rose, the emergence of the term "Sustainable Development" was defined in the Brundtland Commissions report "Our common future", published in 1987. The definition is famously stating *"development which meets the need of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development, 1987). A lot has happened since, but the definition somehow marks the beginning of the increased pressure towards institutions and the public to act on this initiative.

The environment knows no national boundaries. As the global economy has grown more intertwined, and supply- and value chains stretches across the globe – the environmental concerns are something that needs to be managed with all seriousness throughout every echelon in the governmental, political, and corporate hierarchies. Sustainability is in some sense the composition of all actions which do not delimit future generations' resource needs. This can be renewable energy sources, carbon capture initiatives, the phasing out of the petroleum industry, or fully utilizing the resources already available to us, thereby mitigating the environmental footprint and residual waste. The challenge of coping with environmental concerns, with global warming often mentioned as the most urgent measure, is particularly comprehensive due to the complex nature of the challenge (Nordhaus, 2007); implying that policy changes and regulations affect a wide span of societies and disciplines. Ecologist and marine biologist are concerned about ecosystems and ocean acidification, businesses might view global warming as either an opportunity or a hazard, while coal miners consider environmental actions as a threat to their livelihood (Nordhaus, 2007). Simultaneously, technological development and innovation are transforming many aspects of our economies. Technological contribution to the development of automation have created new ways of conducting business, and redefined the means to how new businesses and jobs are organized (OECD, 2020).

With the increasing pressure to operate in a sustainable and responsible manner, many organizations look to the concept of Circular Economy (CE) as a method of approaching and incorporating a more sustainable mindset, and explore the initiatives the CE proposes to create new business models and maintain a thriving economy. "*The Circular Economy refers to an industrial economy that is restorative and regenerative by intention; aims to rely on renewable energy; minimizes tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design"* (Ellen MacArthur Foundation, 2013). The agenda is achieving a positive environmental, social and economic impact through operating in accordance with the cycling principals of energy and resources to replicate natural symbiosis (Ellen MacArthur Foundation, 2013; Grafström & Aasma, 2021).

1.1 Research problem

The Norwegian Government recently presented their plan to fight climate changes toward the year 2030, which includes drastic measures to decrease the carbon emissions and generally phase out our carbon footprint in the economy (Meld.St.13, 2021). Despite the sustainability benefits and profitability possibilities implied by implementing circular business models[1] (CBMs), the traditional linear economic (LE) model is still the most common economic model in both the Norwegian and global market (Circular Norway, 2020). Various studies have identified multiple barriers that disrupt the transition towards CE business models, such as, lack of proper incentives, impractical institutions, inconsistent policies, and high up-front investment cost. Other disruptions to the incorporation of a CE might be low consumer awareness, and externalities not internalised through taxes and subsidies (Grafström & Aasma, 2021; Kirchherr et al., 2018; van Ewijk, 2018). To develop and successfully establish CE business

[1] A CBM articulates the logic in which manufactures or retailers increasingly retain ownership of products, design practices generate more durable products, and facilitates disassembly and refurbishment (Ellen MacArthur Foundation, 2013).

models, economic agents must identify the interrelatedness between the relevant barriers and assess how the interrelatedness can be used as an incentivising tool rather than a degenerative obstacle in the transition toward a CE.

Economic theory indicates that in an economy, resources are utilized and used efficiently through the market forces in that economy. The market forces in play should therefore theoretically ensure that the market is efficient, and resources are utilized at full capacity. According to microeconomic models, resource scarcity and growing demand for those resources are both influential drivers of prices. Despite this, the LE model is the dominant model for production and consumption patterns and behavior. Given this, the solutions that CE models propose to effectively mitigate these effects, do not seem to be as widely utilized as economic theory would predict, since maximizing resource efficiency is an economic intuition, and failing to utilize resources – especially scare resources – is neither in line with economic theory intuition, nor the fight against climate changes through sustainable and circular business models.

For several years there has been a growing interest in both scientific communities and among policy makers to further study the CE as a phenomenon. With the increasing pressure on making environmental and economically sustainable decisions there is reason to anticipate even more growth in the interest of CE concepts. The report from Circular Norway (2020) revealed that 97,6% of the materials consumed in the Norwegian economy is not transferred back into the economic cycle. Thus, despite the recognized attention, only 2,4% of consumed goods are circular (Circular Norway, 2020). Development within the field of economics taking circularity into account would have to incorporate explanatory models for how the economy can operate, given earth's resilience, and on natures premises (Bjerke Soldal, 2021). This portrays that there is an enormous potential to increase circularity in the economy and rethinking our economic models might hold the answer as to how we can successfully achieve this.

1.2 Research question and purpose

This thesis is meant as a contribution to currently existing research on circular economy knowledge, and provide a discussion questioning whether the concept is something entirely new, if the foundations of CE already are familiar to economic theory, and how traditional economic business models could embody CE. The thesis aims to raise some questions as to how humanity have constructed our economic system, and how rethinking and restructuring this economic model can in fact enable economics to be a solution to our environmental concerns. Existing scientific research and economic theory are therefore of high importance to our assessment, which seeks to answer the following research question:

"How does Circular Economy fit Traditional Economics? Incorporating Planetary Boundaries and Environmental Issues in Welfare Economics"

The explorative nature of the research question is formulated to be a source of discussion, simply because existing research seldom draw the parallel between CE and traditional economic models. Nonetheless, to provide insight and a sense of direction in our discussion, we use existing research and theory as means of guidance to further explore this field. More specifically, the reasoning of the Fundamental Theorems of Welfare Economics developed by the cumulative work of several economists since Adam Smith's first development "The Wealth of Nations" are of relevance, as it gives the interpretation of efficient market outcomes and a formulation of price theory.

For further guidance to complement our research, we will include a set of objectives that will ensure that the discussion is in accordance with what we want to describe and achieve:

- Objective 1: *Describe the intention, purpose, and potential of CE.*
- Objective 2: *Identify barriers and enablers in the transition to CE.*
- Objective 3: *Discuss traditional economic theory in relation to sustainability.*

- Objective 4: *Is CE disrupting traditional economics?*

To discuss and answer the above-stated research question and objectives, the thesis will use relevant literature, reports, and studies prepared by government agencies and private consulting firms.

1.3 Delimitations

To further enhance and clarify our research question and objectives, it is important to make some reasonable delineations of the thesis scope. In our study, we have limited our research to publicly and institutionally available literature, as described in section three.

As stated above, the central rationalization of our research is how different aspects of environmental- and sustainability concerns affect traditional welfare economics. The vast complexity and technicalities of the mentioned concerns is best addressed by professionals within the field of ecology or even engineers in relation to assessing the re-utilization of resources. This study is limited to the economic implications of imposing said concerns on traditional economics, by providing a holistic perspective of sustainability and a detailed perspective of the economics. In doing so, we consider a CBM as an organizational structure that individual agents might choose to adopt, and the CE is the network of these agents. Furthermore, this study does not review the mathematical implication of introducing CE and sustainability in welfare economic models. Again, due to the complexity of concerns, there is no single indicator measurement of CE that would align an intervention with traditional models.

In our use of electric vehicles (EVs) and lithium-ion batteries (LIBs) throughout the dissertation, we have restricted research to the Norwegian market. The reason for this is that it is familiar to the authors – providing in depth knowledge of the market, in addition the Norwegian market has swiftly adapted to the electrification of the industry and shows great potential for increased circularity.

1.4 Circular Economy Industries and Relevance

This sub-chapter will provide insight into the EV industry that inherit the potential for CE business models and already pertain some degree of circularity. First, we consider the role of road transportation in the economy, and the footprint left on the climate. Through this paper, this industry is used as an example to clarify and provide insights into CBM challenges and adaptation.

1.4.1 Road Transportation Role in the Economy

In data from 2016, the transport sector was responsible for 16,2% of greenhouse gas (GHG) emissions worldwide (Ritchie, 2020). With an increasing world population and growth in GDP, these emissions from transportation can only be assumed to grow. The use of fossil fueled vehicles (FFVs) contributes considerably to the GHG emissions, in particular through carbon dioxide (CO_2) emissions (Siqi et al., 2019). In addition, the European Commission estimates that half of all GHG emissions come from raw material- and resource extraction and processing (European Commission, 2020b). This contribution has risen substantially in the past few decades as a result of economic growth and extensive use of resources and consumption. CO_2 occurs naturally in the atmosphere and is an essential piece of the fundamental ecological system, however, human activity and consumption have caused, and are still causing, a severe disturbance to Earth's climate system. As we are facing the consequences of our own over-utilization of natural resources, increasing efforts has been put forth over the past few decades to mitigate the GHG emissions and re-establish balance in the atmosphere. An essential contribution towards this is the innovation and electrification of the automotive fleet of vehicles, and sustainable batteries throughout the life cycle are essential to reach the net zero emission goals by 2050 (European Commission, 2020b).

Data presented by the Norwegian institution Miljødirektoratet (2020b) showed that the transport sector in Norway accounted for 31% of the country's total GHG emissions, 55% of which was caused by road transport. Despite the rapid growth in electric vehicles in the Norwegian market, the overall emissions from the transport sector increased by 19% in the period from 1990-2019 (Meld.St.13, 2021). This connection should be considered with regards to a growing population, and a higher willingness to pay, which present the opportunity to consume and travel more.

Even though the road transportation sector is not the sector harming the environment the most, as it falls behind oil –and gas production and industry processes, it still poses a significant climate threat. Especially in regard to the expected growth in the global transport sector, which is expected to continue for decades to come (Hamilton et al., 2020). Considering this expected growth in demand, and the destructive environmental impact of the GHG emissions, the obvious approach is to reduce CO_2 emissions in the transport sector, and lead a transition to EVs - eventually, closing the chapter on the traditional FFVs. As the cost of EVs is presumed to continue its decline, it is expected that over the next decade, battery-powered vehicles in the commercial market will cover most of the transport sector (Miljødirektoratet, 2020a).

1.4.2 The Electric Vehicle Industry and Lithium-Ion Batteries

The market and potential for EVs are growing fast, "*and it is estimated that the demand for batteries is expected to grow from approximately 200 GWh today, to approximately 5000 GWh by the year 2028"* (Valstad et al., 2020). In the last decade we have seen the development from the debut of Nissan Leaf, one of the world's most sold EVs, as well as Tesla taking to the market with their Model S, furtherly driving the competitiveness of EVs to the traditional FFV. The Norwegian fleet of EVs is one of the biggest per capita, due to the particularly liberal EV-strategy imposed by the government and policymakers. There are several reasons why Norway has had such a success in promoting EVs, such as tax relief of expensive one-time fees, access to collective lanes, free municipality parking and no road tolls (Norsk Elbilforening, n.d; Samferdselsdepartementet, 2021). A logical next step toward a CE for EV industry is the expansion of infrastructure for reuse, repair, and recycling of the vehicles, and especially the batteries, which already exist in the economy. The potential is considerable, and the chemical and technical composition of the resources in the batteries hold substantial potential for reuse, decomposition, and recycling.

The strong growth signalized by the market pattern and forecasters, puts increased pressure on the demand and prices for the raw materials used for EV battery (EVB) production. An increased extraction creates concerns to both material use and disposal, as well as the resource efficiency. Particularly the climate footprint from production and disposal of the batteries are issues that receives more attention since the climate changes pose an increasing amount of concern. Following this, the European Commission proposed a legislation in December 2020 that batteries, with particular emphasis on EVBs, must be safe, long-lasting and at the end of the life cycle, they are to be remanufactured and repurposed to ensure that the valuable raw materials are kept in the economy as long as possible (European Commission, 2020c). Several Norwegian corporations are well positioned to benefit from the transition to more sustainable and circular EVBs, such as Elkem ASA (raw materials), Freyr AS (clean energy storage solutions) and HydroVolt (recycling plant for EVBs). Norway then possesses the potential to gain a competitive advantage within green battery technology, with the amounts of available natural resources, technological advances, access to competent labor and in the recycling process of end-of-life LIBs, HydroVolt states to have the capacity to process 8000 metric tons of batteries p.a. and retrieving the valuable metals and minerals from the batteries (The Explorer, 2021; Valstad et al., 2020).

There is no clear answer as to how long the EVs battery lifespan is, considering the continuous development in technology of new batteries, duration and performance is increasing (Melin, 2018). Estimates vary, however, according to an analysis by Geotab, the average warranty coverage of lithium-ion batteries in EVs on the road today is around 8 years (Argue, 2020). As the batteries decay over time, they fall below a certain capacity threshold, which means that they are no longer sufficient to maintain the performance to power a vehicle (Niese et al., 2020). Meaning that a large portion of the EVs sold a decade ago when the sales started to increase, are now reaching the end of their “first life” utilization.

Disposed EV batteries are therefore piling up and the resources needs to be managed and recycled, re-manufactured or reused in a sustainable manner.

The European Commission have recently published their framework for a circular economy. An important part of this is addressing the rapidly growing industry for EVs and EV batteries, where the goal is to construct a framework to promote sustainability and circularity throughout the value chains. Three areas for increased circularity for EVBs are highlighted, namely (1) second-hand use, (2) recycling and (3) utilization of other resources and/or less import of raw materials from outside the EU (European Commission, 2020a). All of the above-mentioned lack historical data for analysis since the industry is relatively new, thereby limiting availability for analyses (SINTEF, 2020).

1.5 Climate Change and Climate Goals

This chapter contains background information on climate change and global warming, and how this gives a motivation towards the adaptation of CE and CBMs. Additionally, we present some of Norway's climate goals and policies towards the new business model.

1.5.1 Climate Change

The term "climate change" have gained increasing interest in the public debate, enforcing policy makers around the world to take measures to mitigate the human contribution to these changes. "Climate change" and "global warming" are often used interchangeably, there is however important distinctions between the two. Climate change refers to the growing changes in the measures of climate over a long period of time, or simply the general weather conditions of a place, regional or global. It is characterized by significant variation in the average weather conditions, contributing to rising sea levels, warming oceans, glacial retreat, extreme weather, ocean acidification and global temperature rise (United Nations, n.da). Global warming on the other hand refers to the rise in global temperatures mainly due to the increasing concentration of GHG in the atmosphere. Due to human activities, primarily fossil fuel burning, heat-trapping GHG generates a long-term heating of Earth's climate system (NASA, 2021). Global warming is thereby a contributing cause to climate changes, and both is typically not specified to only a region or country but is rather measured on an average global scale.

A key characteristic of climate change includes its immense complexity, often misunderstood and never entirely predictable, which in turn creates uncertainty (Moser, 2010). Earth's climate has for thousands of years experienced natural cycles and variations, caused by the sun's intensity, volcanic eruptions, Earth's orbit, and CO_2 levels (Climate Change Committee, n.d). While there still exist some disagreement as to whether recent fluctuations in the global climate is caused by human – and economic activity – the discussion today is centered around what we can do to mitigate our impact and become climate neutral. Today's records, as observed in figure 4, suggest that global warming, particularly since the mid-20th century, is transpiring quicker than ever before and cannot be explained by natural causes alone (Denchak, 2017).

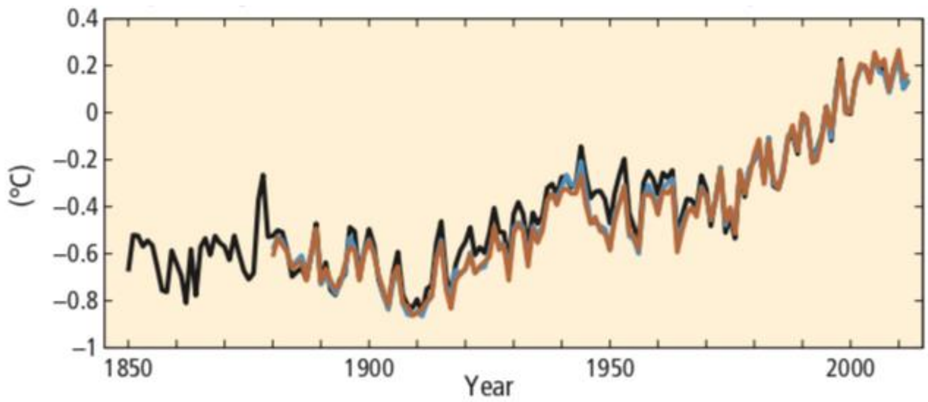

Figure 1: Globally average combined land and ocean surface temperature anomaly (IPCC, 2015).

In fact, according to the fifth assessment report from the International Panel on Climate Change (IPCC), scientist and researchers are 95% certain that human activity is the main cause of global warming (IPCC, 2015). They report that more than half of the cumulative anthropogenic CO_2 emissions between 1750 and 2011 have occurred in the last 40 years (IPCC, 2015). The significant increase in CO_2 emissions, depicted in figure 5, have forced a disruption in Earth's climate system, increasing the temperature levels on both land and sea. As stated by

IPCC, it is extremely likely that the cumulative of these anthropogenic GHG emissions is responsible for more than half of the observed increase in global average surface temperature. To reach a situation with net negative emissions, which is achieved when more GHGs are stored compared to that released into the atmosphere, climate actions need to be on the agenda.

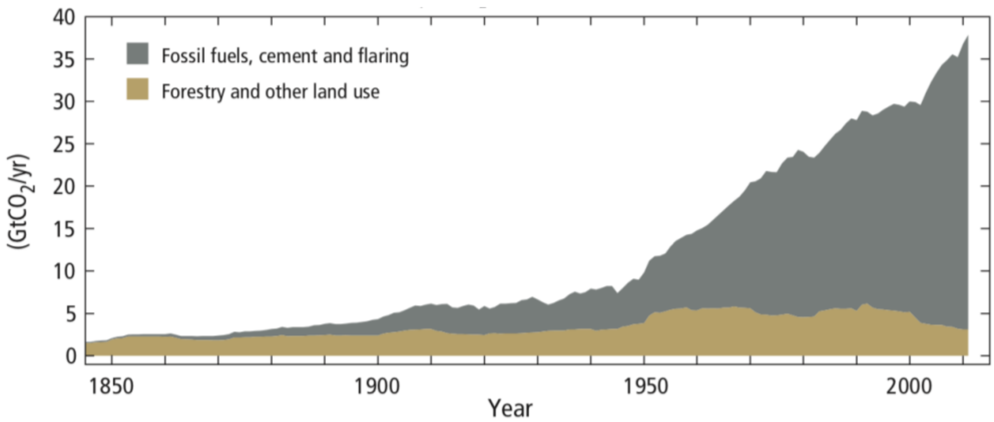

Figure 2: Global anthropogenic CO2 emissions (IPCC, 2015).

1.5.2 Climate Goals and the electrification of road transportation

As a result of climate change and global warming, reducing CO_2 emissions have become a central part of policy – and decision making in Norway and across the globe. In 2015, the Paris Agreement was adopted by 196 parties as an effort to unite and guide nations towards a more sustainable path. As of today, USA is the only country which have made the controversial decision to withdraw from the treaty which goal is to limit global warming to well below 2, ideally to 1,5 degrees Celsius, compared to pre-industrial levels (United Nations, n.db). Norway’s most recent submission to the Paris Agreement was in 2020, in which the country enhanced its national determined contribution target of reducing GHG emissions from 40% to at least 50% and towards 55% compared to 1990 levels by 2030 (Miljødepartementet, 2020).

In order to create transparency and clarity, along with complying and reporting to the Paris Agreement, Norway also report on climate development and measures to several other institutions. Such as the UN and its climate convention and the EU and its climate agreement (Meld.St.13, 2021). According to Klimakur 2030 (2020a), the emission reduction potential of CO_2 equivalents in the road transportation sector in Norway is 11,8 million kilotons. Overall, electrification measures provide a reduction potential of approximately of 13,6 tons of CO_2 equivalents, which make up 34% of the total potential. This includes heavy duty machinery, stationary power sources and conversion to electrified industrial processes. As CE models propose that disposed EV batteries might be re-used in a "second-life" approach as stationary reserves, this could amplify the potential reductions. As of today, battery powered vehicles has the most developed technology and the best potential for emission reductions within the sector (Miljødirektoratet, 2020a).

The comprehensive climate goal of the Norwegian government mentioned above, is defined in the national climate plan, and targets up to 55% reduced GHG emissions. The same target is valid for the transportation sector (Meld. St. 20, 2021). In their effort to achieve this target the plan emphasize that it will still be beneficial for consumers to acquire zero-emission vehicles compared to combustion engines, in addition to supporting technology development and public purchases of zero-emission transport vehicles. The goals of the national climate plan are further enhanced and detailed in the Nasjonal transportplan 2022-2030 (2021), which states the following:

- New passenger vehicles and light vans shall be zero-emission vehicles by 2025.
- New city buses shall be zero-emission or using biofuel by 2025.
- By 2030, 100% of heavy vans, 75% of long-distance buses and 50% of trucks shall be zero-emission vehicles.
- By 2030, distribution of goods in the main cities shall generate close to zero emissions.

1.5.3 United Nations' Sustainable Development Goals

The United Nations (UN) and the world leaders agreed in 2015 to collaborate and construct 17 sustainable development goals (SDGs). The intention of the SDGs is to provide a clear framework and tangible guidelines toward responsible and sustainable. They are constructed such that all organisations, governments, and agents have specific goals to dedicate their work towards, addressing concerns such as elimination of poverty and inequality, and fighting the drastic climate changes we face (United Nations, 2015). The CE and CBMs directly address the SGDs: *Decent work and economic growth (8), Industry, innovation, and infrastructure (9), Responsible consumption and production (12),* and indirectly facilitate *Climate action (13)* and *Partnerships for the goals (17)*.

The framework is not obligatory to comply to, however, with the recent increase and focus on sustainable development and responsible business operations, an increasing number of agents and organisations require that their business partners both up-stream and down-stream do in fact to some extent comply. The framework allows for organisations to have specific goals to consider in their operations, and they gain more traction and importance in compliance in society. Governments are also incorporating the SGDs in their national climate plans as we move closer to the year 2030.

2 Theory and Literature

2.1 Circular Economy: The Concept and its Limitations

In the following sections we present the concept of CE. To provide insight and context of this typology, we include a brief section about the current linear economy model and the CE model. Later, the thesis identifies the several apparent barriers for the transition, and relevant economic theory facilitating this.

2.1.1 The Linear Economy Model

The modern economic model and pattern for consumption and production is primarily concentrated around the capitalistic LE model. This model consists of resource extraction, processing and production of low-quality goods, distribution, and one-time consumption, generally over a brief period before the end-of-cycle disposal. The LE is characterized by low-cost energy such as oil and coal, cheap virgin raw materials and labor from outsourcing, which has led to collective massive over-consumption, especially in the West and large economies such as

China. The blueprint for this economic model is not in line with sustainable models, or the definition of sustainability (Sariatli, 2017). The LE do without question come at the cost of future generations, in terms of access to natural resources and the pollution forced upon the globe.

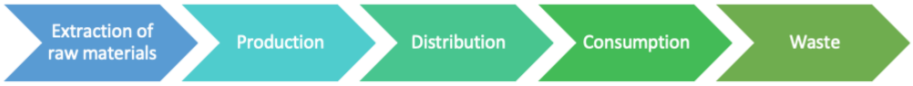

Figure 3: The Linear Economy model

The LE is degenerative by design and deteriorates the planet's natural resources. It has been the fundament for substantial wealth and economic growth since the first industrial revolution, at which time production and consumption patterns took a turn toward non-renewable resources and non-renewable energy sources. Since, the LE model has been responsible for the deterioration on the climate and globe, and if not adjusted to modern day challenges, we may face the destruction of the natural ecosystems. Waste can be argued to be a construction of humanity since natural ecosystems knows no waste and takes full advantage of natural resources through the natural symbiosis by repeatedly entering resources into the ecosystem for new cycles to be followed.

2.1.2 The Circular Economy Model

Since the world is facing limited resources and a rapidly growing population, the linear economy model is becoming dysfunctional, and our wealthy lifestyle is advancing a threshold of which we cannot return from. We need to abandon the linear economy and find ways to restructure the production and consumption patterns over to a sustainable economic model. Today, only nine percent of the world's resources

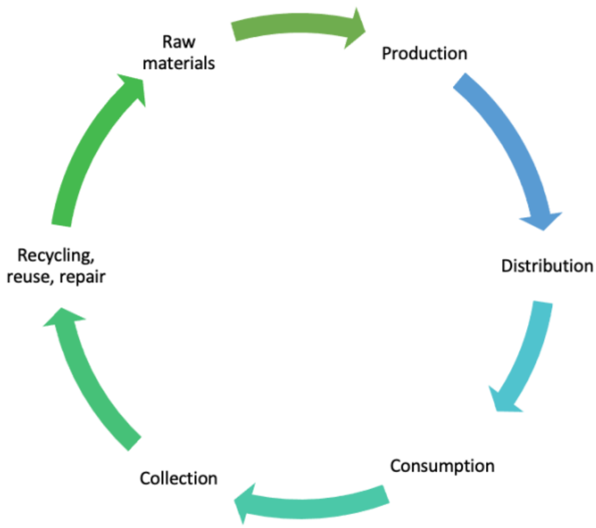

Figure 4: The theoretical Circular Economy Model

are recycled and reused, allowing them to re-enter into the economy. This means that approximately 91 percent of the raw materials extracted do not find its way back to the economy, but are rather transformed into waste (Boye, 2019). The Circularity Metric[2] in Norway is only at a staggering 2,4%, in addition to having one of the world's highest levels of consumption per capita, at 44,3 metric tons per year. This implies that over 97 percent of the goods produced and consumed doesn't re-enter the economy (Circular Norway, 2020).

As early as the end of 2015, the European Commission disclosed a strategy toward making the EU circular, with propositions to legislations toward ambitious climate goals, with particular focus around material recycling and waste management (European Commission, 2020b). Since Norway is a member of the European Economic Association (EEA), the legislations and circular strategy from EU are binding, and have been incorporated in our country. However, we still do not meet these requirements toward 2025, and reports do in fact show that the world became *less* circular from 2018 with a circularity metric of 9,1%, down to 8,6% in the year 2020 (Circular Norway, 2020). A major challenge is that many of the legislations and strategy toward a more circular economy addresses waste management, rather than focusing maintaining the resources in the economy in the first place. If we succeed in keeping the resources in the economy, waste management concerns will fade, since the resources refrain from becoming waste at all. Another problem with the transition from a linear economy to a circular economy, is that the linear economy is still highly profitable and has been the fundament for massive wealth creation, thereby maintaining the attractiveness for continuing the same production pattern rather than becoming more circular. Aligning interests for profitability and sustainability for industries is considered essential in order to succeed in the transition from the linear economy to a circular economy.

The CE is an economic model where also waste is an important resource for future utilization. The goal of a CE is to detach us from the dependence of raw

[2] The degree of circularity in percentage, measured by the goods and services that re-enter the economy (Circular Norway, 2020).

material extraction, and rather produce, design, and utilize our goods and services in a way that is sustainable, to keep the resources in the economy, ensuring circularity. This requires that the goods demanded and produced sustain an increased lifetime, more robustness and they can with less effort be transformed into new goods and services. Waste must also be material-recycled and utilized as raw materials in the remaining cycles – namely secondary raw materials in new production. The resources and raw materials used in new production then do not leave the economy, reducing waste, capital and resources spent on waste management and reducing extraction of primary raw materials. This process can reduce greenhouse gas emissions from extraction, reallocate resources spent on extraction toward material recycling, and in turn reduce harmful waste and emissions from waste management.

To provide sustainable short- and long-term value creation, circularity maximizes the utility of all resources, both primary and secondary raw materials, so that there ultimately is no residual waste (SINTEF, 2020). There are numerous ways to maximize the utilization of resources, which together with re-utilization establishes a foundation for a circular economy. Prolonging the lifetime of goods and services is essential, as we want the resources to last longer, maintaining quality, value, and endurance for as long as possible. In the life-prolonging processes, the resources are fully utilized before reuse or recycling finds place, which both extends the life and use of the goods through quality and ensuring that no resources or production capacity goes to waste. Designing goods in a way which makes it possible to remanufacture them, increases the potential for circularity.

2.2 Ecological Limitation on Industries and Economics

Customizing humanity's economic and social systems within the boundaries of the planet is becoming an increasing concern, and requires substantial reconsideration of our needs, and production- and consumption patterns thereof. Our planet doesn't have unlimited supply of resources, and the integrated LE does in some sense fail to incorporate this constraint.

2.2.1 Ecological Economics and Industrial Ecology

Ecological Economics (EE) incorporates the planetary boundaries of resources into our economic models, and stem from the field of ecology. It stands to evaluate the impact of our economic behaviors and interactions on social and environmental aspects (Korhonen et al., 2018).

Industrial Ecology (IE) aims to merge the industrial systems and the natural ecosystems together, constructing a framework for viable and environmentally friendly industrial systems (Walmsley et al., 2019). IE is an important aspect in EE, which introduces the life cycle aspect into industrial economic models such that surplus resources from one system or life cycle, can be reutilized as a resource in another life cycle. IE is a framework used to enable economic industrialization while considering and incorporating the ecological and environmental aspect of the cycles into the industrialized system. A common tool that has been widely applied in IE is the life-cycle assessment (LCA), which evaluates the environmental impact from extraction of raw materials to the end-of-cycle for the final goods and services produced (Bruel et al., 2018).

The main point of EE and IE is to incorporate limitations and enablers from ecology to provide an industrialized economic system which considers the natural symbiosis' flow of energy, matter and information in production and consumption of goods and services. More precisely, how our behavior impacts and deteriorates the environment, which in turn can assess how the system can be utilized to construct a CE.

An efficient CE model is a closed loop economic model that optimizes the virgin resources and raw materials use, reducing both GHG emissions and waste, whilst enabling a functioning ecosystem for industrial production and consumption as we are familiar with today. The LE operates without considering planetary boundaries of resources and pollution and pose a trade-off between economic growth and environmental impact. IE and EE in CE introduce nature and planetary boundaries as a constraint in the model, being a more accurate and realistic representation of in comparison to the open-loop and deteriorating system in which the LE operates with.

2.2.2 Doughnut Economics

The 20th century's economic models are based on goals and economic indicators for everlasting growth in GDP, and general economic growth. This goal of economic growth was interpreted as a solution to the challenges they faced at the time the models were developed. Thus, what these economic indicators fail to consider is that infinite growth with a finite supply of resources is not feasible as we know it. In addition, the models fail to consider the environmental impact which followed. Due to the lack of incorporation of long-term effects of the model developed, economies have become degenerative rather than regenerative by design. The "Doughnut Economy Model" is a regenerative economic model which is constructed in a way such that economies can thrive in a type of "goldilocks zone". The doughnut theory incorporates planetary boundaries as well as social standards and welfare in the model, striking a much more realistic and sustainable economic design. Acidification of the earth's oceans, causing climate breakdown due to disruptions in the natural ecosystems, and severe biodiversity losses, are therefore factors that should be considered in 21st century economics (Raworth, 2017).

Given the challenges we face today, there is a need for rethinking economics, and redesign our economic models to incorporate the problems and challenges we face today. Traditional economics were developed at a time where the challenges then were not the same as we in fact face now. Kate Raworth proposes that there is a need to change the goal of economics from GDP growth to the doughnut, where instead of immensely striving to achieve economic growth, the models use the resources already provided in the cycle and infer social and planetary boundaries. She argues that for economies to thrive, the economic models should operate around the means of the planet we live on. The doughnut ensures no one falls short of the essentials in life, while not overconsuming, and overproducing at the expense of both the planet and our future generations.

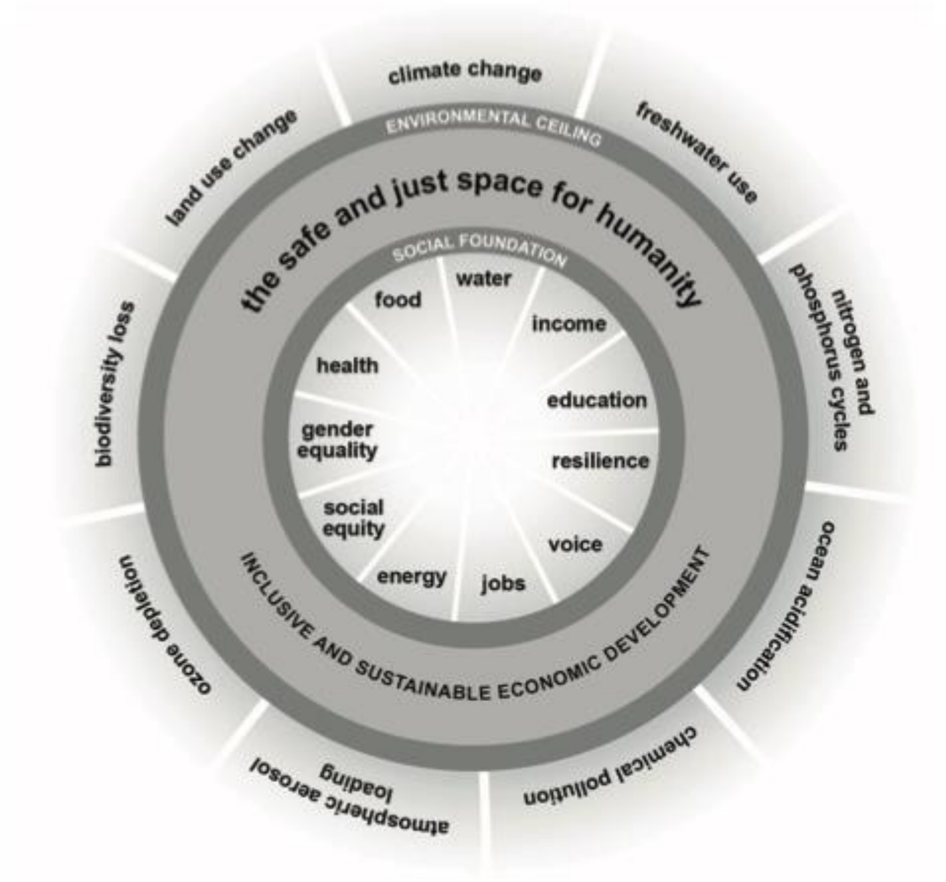

Figure 5: Doughnut Economics (Raworth, 2017).

2.3 Barriers Toward a Circular Economy

There are several barriers to overcome to successfully implement a CE. The capitalistic linear economy model has been the basis for substantial wealth-creation over the last decades, and out modern economic habits and behavior greatly rely on and revolve around it today as well. Therefore, the transition from a LE to a CE requires substantial changes collectively in production and consumption patterns, regulations and sufficient economic incentives and subsidies.

The identified barriers in this section applies to the general implementation of CE systems across industries. In order to reach full circularity throughout any industry or value chain, a prerequisite is collaboration across both industries and international borders. The barriers may hold some degree of interrelatedness between them, and the transition to a CE requires overcoming these barriers in their entirety.

2.3.1 Cultural and Knowledge Barriers

Kirchherr et al. (2018), addressed several factors which can clarify cultural barriers for the transition to a CE from a cultural aspect. The most pressing were *lack of consumer interest and awareness, hesitant company culture,* that the *companies currently operate under a linear system*, and *limited willingness to collaborate throughout the value chain*. Both "companies operating under a linear system" and "limited willingness to collaborate throughout the value chain" seem to be reinforcing subsequent barriers. Companies cannot deliver and supply fully circular goods unless the whole value chain is circular, which facilitates further negligence of the transition toward a CE. Hesitant company culture further mitigates the willingness to collaborate through the value chain as well as with other collaborating partners.

The white paper "Breaking the barriers to the CE" (2017) published by the consultancy agency Deloitte identifies the same categorical barriers as above. For companies to benefit from the green transition with circular products, there is a requirement for all agents to comprehend the value of what the CE represents. Rizos et al. (2015), reported that consumers have limited knowledge about the concept and subsequently gives CE low priority in individuals decision process. The lack of knowledge to what the concept of circularity inherits make it difficult for both consumers and organisations to make informed and responsible circular decisions, both from production and consumption aspects (Preston, 2012). An important barrier is therefore *established habits and attitudes*. Should the local governments and EU communicate the CE's feasibility and advantages, as well as the importance for mitigating climate changes more substantially, it needs to operate transparently, use open communication, and provide directive standards. Increased awareness would provide a more robust standpoint for implementing CBMs and incentivise potential CE resistant managers.

2.3.2 Regulatory and Political Barriers

Several respondents in the report "Kunnskapsgrunnlag for nasjonal strategi for sirkulær økonomi" (2020) identifies that *lack of long-term political strategies and framework* can pose as barriers for CE in Norway. *Lacking global consensus* is another regulatory barrier identified, addressing the issue of a global consensus and international collaboration obstructing a CE (Kirchherr et al., 2017). Domestic policy framework and regulations only have so much impact on the CE, and until international collaboration on circularity obtains consensus, it is difficult to establish entirely circular value chains across the globe. Such factors can become obstacles for organisations to infer and implement research and development (R&D) to innovation and solutions for circularity.

Political coordination, clear guidelines, framework, and *legislations* are all essential influencers should the transition to a circular economy be successful. The existing framework is concentrated around the LE, and a CE requires reorganizing the approach to what is defined as resources and waste, as well as who should be the responsible parties to handle them (Deloitte, 2020). For instance, some laws and regulations could potentially hinder the use of recycled resources in new products, or there might exist laws that prevents waste trading across international borders (Kirchherr et al., 2017). Another general concern is also how the system for taxation, subsidies and fees is structured. The existence of subsidies that still support the LE, such as subsidizing the energy-use of virgin resources extraction, might diminish the attraction to circular processes (Kirchherr et al., 2018). As long as policymakers and government doesn't provide clear guidelines and regulations for the use and consumption of public goods and services, the transition will likely be slow if transitioning at all (Deloitte, 2020). The lack of ambitious goals for waste management is also a factor which plays an important part in the regulatory barriers toward CE implementation.

2.3.3 Market and Economical Barriers

The most important economic barriers in regard to CE transition is the profitability aspect. *Low virgin material prices* and *high up-front investment costs* with risk are two of the most highlighted sub-categorical economic barriers

(Flachenecker & Rentschler, 2019; Kirchherr et al., 2018; Rizos et al., 2015). *Limited funding for circular business models* is also an important sub-categorical economic barrier. It is important to create sufficient economic incentives to succeed in the transition toward a CE, or more precisely, providing competitive advantages for circular models compared to the current linear, highly profitable, economic model. An example provided were that fossil-fuel based plastics are much cheaper compared to bio-based plastic products, which diminishes the competitiveness of circular or secondary raw materials (Kirchherr et al., 2017). Increasing the prices of low-cost virgin materials can followingly strengthen circular and secondary raw materials with decreasing margins on primary- and virgin materials compared to circular materials.

Since circular goods have yet to be proven sufficiently profitable and viable in the market, high up-front investments are considered risky and costly since the first significant investments are likely to lose money (Kirchherr et al., 2017). Risk-willing capital is considered scarce, and first when circular goods and models are proven to be profitable, the rest of the market will be willing to invest furthermore as projects become more profitable investment cases. High up-front investment costs may also be a factor in hesitant company culture from the cultural barrier aspect, as CE is considered too expensive to initiate, and maintain profitability.

The pricing of GHG emissions and actual cost to the environment are factors contributing to the expanse and use of low-cost virgin materials. Cheap virgin materials, low to zero taxation and fee-structures on primary materials, as well as expensive (both in terms of actual prices and input factors to develop) circular materials all reduce the willingness to develop, produce and utilize circular resources (Deloitte, 2020). It is not sufficiently profitable to establish infrastructure and systems for collection, sorting and material recycling. The market for this industry is too small to be able to fully utilize products which consist of secondary and circular resources and raw materials. Though the market for secondary raw materials and circular raw materials today is not sufficiently scaled, it is possible to succeed in the transition. However, this requires that goods and services produced are designed with quality and durability in mind as well as the possibility to disassemble the goods after use. The design phase of the goods and services are essential, and stand-alone determines approximately 80% of the environmental footprint of the good (European Commission, 2020b). An industry for collection and sorting of produced and already utilized goods therefore also need to be in place, otherwise recycling plants may find it complicated and comprehensive to provide this service as well.

2.3.4 Technological Barriers

Having sufficiently developed technology is a prerequisite for the CE transition (Kirchherr et al., 2018). The four most pressing subsequent technological barriers identified in CE literature are *circular design*, *ability to deliver high-quality remanufactured products*, *lack of data on impact* and *too few large-scale projects* (Kirchherr et al., 2017). It can be argued that the technology needed for CE is present and is sufficiently sophisticated, however, it is not customized and utilized with circularity in mind. The technological barriers are therefore dependent on attractive incentives to adapt circular measures into current technology. To develop goods that are circular-friendly, there is a basic need for designing the goods thereafter. Innovation and further technological advancement in the process for producing, collecting, and reusing, and recycling the goods in the economy is important to obtain and make circular goods viable, as the design of the products themselves are insufficient to achieving circularity through the value chain.

Digital immaturity, lack of digital infrastructure and lack of sufficient data are key factors for areas of improvement to successfully develop, design and produce circular goods which can in turn re-enter the economy and be subjects to remanufacturing (European Commission, 2020a). The lack of true-time data for waste management and resources are obstructing optimal production patterns and does not currently provide predictability in access to secondary and circular resources to meet the needs of quality standards and prices to further implement an infrastructure for circularity (Kirchherr et al., 2018). Publicly accessible data is important to map and analyze what raw materials, goods and services which can be recycled or reused, and pose as a barrier for the implementation of necessary infrastructure, since the untapped potential in this industry is overlooked due to this. An important contribution to the data aspect is to increase the degree of LCA. Data collected from the LCA can be utilized to map out consumer behavior and their respective preferences to adjust production thereafter.

Cultural and knowledge	Regulatory and political	Market and economic	Technological
Hesitant company culture	Lack of long-term political strategies and framework	Low virgin material prices	Lack of circular design
Lack of consumer interest and awareness	Lacking global consensus	High up-front investment costs	Lack of ability to deliver high-quality and durable remanufactured products
Limited willingness to collaborate throughout the value chain	Lack of political coordination and legislation	Limited funding for circular projects	Lack of data on impact
Currently operating under a linear system	Lack of incentives from governments and policy-makers	Standardization	Too few large-scale projects

Figure 6: Barriers Toward a Circular Economy

2.4 Fundamental Theorems of Welfare Economics

“The Wealth of Nations” published in 1776 by Adam Smith might be one of the most influential works within the discipline of economics. Especially for those concerned about how to best allocate and coordinate society to enhance general welfare his work serves as the basis for how competitive markets is providing an efficient way of organizing economic activity and policy. Smith’s insights are relying on market forces and individual's self-interest to ensure that an efficient market is attained (Stiglitz, 1991), often referred to as laissez-faire. As Smith’s work formulated the outline of welfare economics in social science, which still can be seen in the structure of modern economics today, many economists have interpreted and further developed Smith’s insights. Smith’s ideas about the relationship between market economy and the public interest, his formation of price theory, his analysis of sources of economic growth, and his reflections on the role of the state are central in modern economy theory (Sandmo, 2014).

The ideas and insights presented by Adam Smith shaped the body of modern economics, and there exist a debate as to whether more recent work is merely attempting to clarify, expand and mathematize Smith's work (Boulding, 1971). Nonetheless, extensions from Léon Walras, Francis Y. Edgeworth, Vilfredo Pareto and Kenneth Arrow, seeking to determine in which circumstances the assumptions of general equilibrium holds, have accumulated to the welfare economics we know today. In principle, it concerns how allocation of resources and goods affects social welfare. By identifying welfare through the satisfaction of societal and individual preferences, it uses the methodology as a tool to achieve beneficial social and economic outcomes through public policy. It aims towards an economically efficient distribution of resources for the overall well-being of society. Adam Smith's claims on public interest and market effects led later economists to explore the notion of competitive markets in order to discover more precise analytical justification of Smith's claims (Sandmo, 2014). These extensions, amongst others have formed The Fundamental Theorems of Welfare Economics (Stiglitz, 1991).

2.4.1 First Theorem of Welfare Economics

The First Theorem of Welfare Economics states that, under certain conditions and an assumption that all individuals and firms are self-interested price-takers, or maximizers, any competitive market equilibrium in the economy is always Pareto Efficient (Varian, 2020). Suggesting a perfectly competitive market serving as a hypothetical benchmark for measuring efficiency in market outcomes. Based on several assumptions for the ideal conditions of free markets, environmental concerns and resource issues are addressed as they arise in an economy where markets are the presiding factor of supply and demand. The set of assumptions characterizing such a free market include the following (Perman et al., 2003; Varian, 2020):

- There exists a market for all goods and services
- Markets are perfectly competitive

- All agents have perfect information
- Private property rights are fully assigned in all resources and commodities
- No externalities
- There er no public goods, only private goods
- All utility and production functions are 'well behaved'

The general notion is to let market effects self-correct the potential inefficiencies or market failures, without any governmental intervention. Furthermore, the theorem argues that equilibrium is attained when all the gains from trade have been exhausted and there is no more voluntary exchange. Such a trade is characterized by a gain of one agent without making anyone else worse off, known as a Pareto improvement. "*When all such gains have been made, the resulting allocation is sometimes referred to as Pareto optimal, or Pareto efficient*" (Perman et al., 2003, p. 107)

2.4.2 Second Theorem of Welfare Economics

The Second Theorem of Welfare Economics explains if all agents have convex preferences, then there will always be a set of prices such that each Pareto efficient allocation is a market equilibrium for an appropriate assignment of endowments (Varian, 2020). Provided with the market competitive mechanisms and lump-sum taxes and transfers, then virtually any Pareto optimal equilibrium can be achieved. When taxes and transfers is redistributed from the agent who is better off to the agent who is worse off, a new efficient allocation is attained. This theorem allows for separation of efficiency and distribution matters (Perman et al., 2003). Thus, those supporting government intervention will ask for wealth redistribution policies.

At the core of welfare economics and the fundamental theorems is the equivalence between a competitive market equilibrium and a Pareto optimal allocation. While a competitive equilibrium is the situation where all agents take prices as given and adjusted to bring equality to supply and demand in all markets. A Pareto optimal allocation is the situation when there is no waste in the economy, often described as an allocation where it is impossible to improve the outcome for one agent without making someone else worse off. As a consequence, society's resources are consumed efficiently and under complete conditions the market economy generates no waste (Sandmo, 2014).

The theorems are relevant because we believe that resources are being wasted in the sense that opportunities for circularity in resource management are not being utilized to its full potential, or not at all in some markets. In our discussion in section four, we elaborate in greater detail how traditional economics might prove to be somewhat outdated, not accounting for the environmental factors that have emerged in later decades.

2.5 Market Failure and Resource Efficiency

The Fundamental Theorems of Welfare Economics describes the theoretical logic behind the pathway to efficient market outcomes, given that certain conditions such as perfect competition and perfect information is fulfilled (Varian, 2020). In practice, this theoretical ideal outcome proves more difficult to achieve. On some occasions' markets might prove to be inefficient, indicating that there exists some sort of market failure. A market failure might occur when attributes of markets impose a situation where markets do not deliver an efficient outcome to society. According to standard economic models' resources should be produced and consumed efficiently, however, in a situation with market failure resources might go to waste instead of being utilized to its full potential. In the neoclassical economics framework, market failure is possible if there exist externalities, public goods, asymmetric information, market power or absent markets, which creates a potential waste of productive inputs. Although markets are competitive, the presence of these external effects prevents the market from self-correcting potential inefficiencies (Stiglitz, 1987).

The mere existence of these external effects does not necessarily invoke market failure; however, it could potentially lead to failure in comparison to the perfectly competitive model equilibrium. The term externality often come up in the literature and is typically associated with market failure. Externalities are uncompensated costs or benefits of economic activity that fall upon people not party to the actions in question (Andersen, 2007). In the case of negative externalities, such as pollution, the "Pigovian taxes"[3] are suggested to correct the externality-generating action.

A pure public goods have the property of being non-rival in its consumption, meaning that the consumption of one person doesn't affect the availability for others. Additionally, it is non-excludable which means that other agents cannot be prevented from enjoying the good (Perman et al., 2003). As an example, national defense is often characterized as a public good, in the sense that it is not the exclusive property of any one person or group. If one person in an area is getting protected, others in the same area are likely getting the same protection.

Asymmetric or imperfect information is another source that might lead to inefficient markets, and it occurs when one party to an exchange has relevant information that the other party does not (Stiglitz, 1987). To achieve an efficient market outcome, one must attain complete, unbiased and certain information, if not, participants of the market will make sub-optimal decisions that will affect the over-all efficiency of the market as an allocator of scarce resources (Andrew, 2008).

2.6 Network Effects and Circular Economy

Katz and Shapiro (1985) describe network effect in the following way: "*There are many products for which the utility that a user derives from consumption of the good increases with the number of other agents consuming the good*". All of which inherits the characteristic where an individual consumer buying decision is influencing the decision of other individuals in the market for the same good or

[3] The Pigouvian "*tax is intended to tax the producer of goods or services that create adverse side effects for society*" (Kagan, 2020), by redistributing the cost the external cost back to the producer.

service (Weitzel et al., 2000). The general idea of "Network Effects" is a scenario where a business has a value proposition of a service or commodity which yields a higher value, for both existing users and shareholders, with an increasing number of users and usage (Katz & Shapiro, 1985). Even though networks grow larger, this does not necessarily lead to a decrease in costs as the theory of economies of scale (EOS)[4] would predict. Rather the opposite might happen in the presence of network effects – as the value of the service or commodity increases exponentially, the costs might increase linearly with each unit added to the network. Network effects, often referred to as network externality, will usually have an impact on the strategic behavior of firms due to the demand-side increasing returns to scale (Majumdar & Venkataraman, 1998).

The two authors Michael L. Katz and Carl Shapiro makes the distinction between direct – and indirect network effects. The direct network effect is often the most visible, as each new user of a service or commodity adds value to existing users. There is a direct physical effect as the utility of a consumer purchasing a product depends on the number of other consumers that have joined the network (Katz & Shapiro, 1985, 1994). Indirect network effects propagate somewhat different in response to a network externality. The hardware-software paradigm is used describe the effect. The authors state the following:

> An agent purchasing a personal computer will be concerned with the number of other agents purchasing similar hardware because of the amount and variety of software that will be supplied for use with a given computer will be an increasing function of the number of hardware units that have been sold. (Katz & Shapiro, 1985)

These effects have different applications and are evaluated different depending on which network the potential buyer is in (Weitzel et al., 2000). The network effect is a theory of potential exponential growth. The value of such a network was

[4] *"EOS is the theory of the relationship between the scale of use of a properly chosen combination of all productive services and the rate of output of the enterprise"* (Stigler, 1958)

described by Robert Metcalfe and Metcalfe's law which states that the value of a telecommunications network is the square root of the number of connected users in the network. In this situation the network effect is gaining traction and attracting users to the point where it reaches the so-called "critical mass". The point of critical mass is where the network effect becomes more and more significant. Once critical mass is attained, the value proposition attracts new users because of the utility offered by joining the network – it is the number of users needed for the network effect to take hold. Businesses that reach this point becomes to some degree self-sustained and thrives of the increased awareness of benefits to joining the network.

Despite the enlarged and growing networks, there still exists market competition between and in these networks. Katz and Shaprio (1994) brings forth three issues regarding network market competition, focusing on *influencing expectations, facilitate coordination*, and *achieving compatibility*. First, rational buyers must form expectations of the availability, price, and quality of necessary components for future investments, as investments often spread out over different periods. The issue of coordination in networks is both among firms, and sometimes among consumers as well. The coordination required can be tools of common ownership and of various components suppliers, long-term contracts, industry-wide standard-setting bodies, and standardization. The third issue is of compatibility and to what length should suppliers go in producing components that is compatible across multiple networks and platforms. These three issues are further applied in the discussion of network effects and circular business models, in section four.

2.6.1 Markets to Illustrate Network Effects

Some markets are determined by strong positive network effects, deriving from the need of product compatibility. The markets that are most mentioned in relation to network effects are telecommunication, information technology sharing markets such as social media platforms, and e-commerce sites. The reason for the clear and apparent network effects in these particular markets stem from the need for compatibility to exchange information or data, and the need for complementary products and services (Weitzel et al., 2000). To rephrase, if there existed only one individual who owned a mobile telephone, the intended function of the phone would disappear, and there would be an incentive to develop any complementary services such as the internet. Other examples are e-commerce websites such as eBay and Amazon, which gained massive crowds of users when they went online, attracting both sellers and buyers to utilize their respective platforms. In establishing an e-commerce site with many sellers, which supply a wide variety of products, these websites attract many buyers, which in turn, attracted more sellers, creating more marginal added value to the sites per user.

3 Methodology

This thesis aims to be a contribution to the existing research on CE, and to shed light on and raise some questions on how the CE model has been constructed, how it differs from the traditional LE model, how the CE model fits traditional economics. Therefore, the methodology practiced in this thesis might differ from traditional research papers.

3.1 Conduction of research

Initially, we investigated what type of research and literature existed in the field of CE, and their respective angles and aspects to the economic model. Furthermore, we investigated whether or not any comparisons were identified with the CE model in regards to the current LE model. We found several relevant articles and literature on CE as an economic model and concept, in addition to government institutions' plans to fight the climate challenges through increasing circularity. These articles and literature were used to form a deeper understanding of the CE model and further enhance our interpretation and grasp of the model. Further on, we attempted to collect literature on the transition from a LE to a CE, what barriers might exist obstructing the transition, and how the CE address modern challenges such as resource scarcity and excess GHG emissions. Little research and articles directly addressed these concerns, moreover, an even fewer number of articles and literature concluded on any direct approaches for the transition. Nevertheless, theoretical transition from a LE to a CE were discussed in the literature. However, the different literature lacked a holistic view of the model, and implications to society from deviating from the economic path developed in the 18th century. Therefore, we structured our thesis in such a way that we assessed the relevant literature collected, and utilized our knowledge of economics in combination with the existing literature on the subject to investigate how the CE concept fits traditional economics.

3.2 Collection of literature

We primarily performed our literature search through Google Scholar, since it is widely interconnected and provide access to a variety of different journals, experiments, primary- and secondary literature, and research. In addition, other search webs and databases were sought out for retrieving relevant literature, such as Web of Science, Scopus, Oria, and a handful of books on economics. Despite the wide array of research in these databases, Google Scholar showed most prominent, and was therefore used as our primary database for retrieving the articles and literature in this thesis. In addition to lack of accessibility in other search webs, several layers of blockage were present in most of the other databases, making us unable to retrieve the original articles and literature from other sources than Google Scholar without subscriptions and payments.

Some literature was however not directly linked to CE. In our assessment of the CE model and whether or not it fits traditional economics, we have used other economic theory and aspects such as network effects to describe the CE model in detail, and linked it to other economic and ecological phenomenon which the CE model builds on. We have decomposed the CE model to assess whether or not it is a new economic model and concept, and used relevant literature to further describe the model, its foundations, prerequisites and the goals of the CE model.

3.3 Method of analysis

The "analysis" in this thesis is rather a critical discussion of the existing theory, where we have provided an assessment of how a transition from the LE to the CE may be successful based on the inherited and normative economic behavior that exist. The assessment also attempted to identify which obstacles should be interpreted in the transition, how the CE framework is structured and whether or not it fits traditional economics. We hope that using existing research and complementing it with a fresh mindset may have formed some questions regarding how the economic model (CE) fits traditional economics.

3.4 Rationale for method and approach

Our rationale for choosing this method of approach is merely that the existing research and literature on CE as a concept and economic model lacks a holistic view of the model. Existing research and literature describe what the CE model is and identify barriers for implementation but lacks foundations on *how* the model can and should be incorporated, and *why* it is considered to be the solution, to the economic and environmental challenges provided by the LE. The CE model seems to be widely accepted by the public, governments, organisations and institutions, however, an insufficient level of knowledge in what the transition to a CE will bring along, and how the model actually fits traditional economics – thereby also our traditional social needs, behavior and disruption to how we live today seems to be little to no knowledge of. Therefore, we found it useful to dive deep into the model's construction, and how it fits traditional economics and our established social and economic behavior.

3.5 Limitations

The findings of this study should be seen in light of some limitations. The lack of research question specific literature, and the impact of grey literature could affect the quality of the assessment and the ability to provide an answer the research question. Therefore, the literature and theory provided will establish a foundation for the explorative nature of the research question being investigated.

There exist a vast number of articles and reports on the concept of CE, but there is a significant gap in the literature when it comes to our research question. Due to this gap, we have also reviewed other relevant publishments and literature from both private and government institutions to complement our thesis. Instead, we use economic theory and sustainable economic models to extrapolate and provide an answer to how CE fits traditional economics, and what barriers exist in order to do so. Such reports and articles are typically referred to as grey or fugitive literature, these are synonymous terms for literature, research and reports prepared by governments, academics, businesses and industries in formats not controlled by commercial publishers. The use of such literature might obscure the objectivity of the thesis because these institutions could potentially have a vested interest in producing findings in a certain way. The lack of literature could also affect the generalizability, reliability and validity of our assessment.

Another limitation is the time constraint related to the thesis deadline. The nature of the research question requires a thorough search and read-through of a substantial number of relevant research and articles. The Norwegian government had scheduled a national strategic plan toward a CE by Q1 of 2021, however, this has not yet been completed or published.

4 Discussion of Findings

4.1 Relevance

Global warming, deterioration of nature, increasing acidity in our oceans, loss of biodiversity and resource scarcity. These are only some of the problems we face, and they are destructive and degenerative to our planet. Our goal of constant and everlasting economic growth, more precisely GDP growth, is harming the eco systems, biodiversity, and climate around us because of the way our economic models are structured. Cheap virgin raw materials and mass production in economies of scale has facilitated a linear economy such that cheap goods and services are consumed at an alarming pace, and the LE has substantiated adventurous growth and wealth creation the last century. However, the effects of this mass production and overconsumption have reared its gruesome effects on the environment. To tackle the severe and fatal effects our economic behavior has on the planet we live on, we need to rethink our economic models such that it is both covers our needs and is viable and sustainable in the long run.

The optimal solution would be an economic model that maintains our wealth, have the potential to increase our well-being, and simultaneously reduce the environmental impact and residual waste. A circular economy which keeps resources in the cycle which increases the resource utilization and -efficiency, minimizes GHG emissions and still allow humanity to thrive on earth in a closed-loop system. But is this possible? And if so, what measurements are needed to obtain such an economic model?

4.2 Circular economy

The term "circular economy" was phrased by Kenneth E. Boulding in his work "The economics of the coming spaceship Earth" (1966). Boulding introduced the term while considering earth to be a spaceship, and the supply of resources only came from earth itself – in a closed loop fashion. Since the earth is in fact a closed loop system, our economic models must incorporate this constraint, otherwise we will eventually clear out all the resources provided to us, further facilitate the waste problem, and the earth will ultimately no longer be viable.

In general, it is implied that a circular economy will be beneficial to society and the economy as a whole. Through minimizing the use of the environment as a trashcan for residual waste and limiting the extraction of virgin resources for economic activity the CE obtains benefits to the society. These potential benefits make sense intuitively, however, this perspective of CE is typically based on physical observations rather than economics (Andersen, 2007). How far should society go in the recycling of materials? As more advanced recycling methods are being introduced and implemented, it enables organizations to recycle goods which previously have not been recycled. On the other hand, at some point as these methods advance, the net benefit of recycling might gradually decline (Andersen, 2007), implying that the monetary and social cost of using and developing new recycling methods diminishes compared to the benefit gained from the recycling.

The concept of CE is intended to align sustainability – and decouple resource use from economic growth (European Commission, 2020a). According to theory of economic growth, usually measured by GDP, technological development is the main source of growth. However, in order for the alignment to be successful we might have to reconsider the definition of economic growth. The arguments of environmental economics and ecological economics is somewhat divided. Environmentalists argues that material recycling doesn't automatically create growth, as it displaces other production activities. However, it does create added value by increasing the number of times each material is utilized. Ecologists believe that even though CE might achieve the goal of reduced environmental impacts it claims that the economy cannot grow forever and that the CE is not enough to create sustainable growth (Korhonen et al., 2018).

4.3 Barriers to a Circular Economy

The transition from a linear economy to a circular economy poses several challenges and obstacles to overcome for successful implementation. The barriers identified are sectioned into the categories: cultural and knowledge barriers, regulatory and political barriers, market and economical barriers and technological barriers.

4.3.1 Interrelatedness in barriers

As discussed in this part, the barriers may likely hold some degree of interrelatedness, forming a final barrier to overcome, namely the collectivistic collaboration barrier. Isolated economic subsidies, policy regulations etc. alone do not pertain the impact necessary to facilitate sufficient collaboration and facilitation for obtaining a CE. The collectivism barrier in intuition describes the need for global collaboration across industries, governments, and the general public to sustain this regenerative economic model. The interrelatedness in the barriers can be explained and is likely a consequence of the spillover-effects in between them. Economic incentives, policy regulations and legislations as well as structural barriers being lifted will likely create the incentive and opportunity for other sectors in the market to run profitable operations and projects regardless of industry. Following economic theory; if there are sufficiently large incentives, and the possibility to enter a profitable market exist, then players will enter given that the potential profits exceed marginal cost of production + cost of entry. Some industries may have larger entry-barriers than others, such as building large production facilities, or in the collection and recycling industry, entry requires risk-willing and up-front investments in infrastructure and advanced technical machinery. Regardless of the incentives or subsidies provided, if the incentives provided are strong enough, players will arise and reap the opportunities presented in the market. This can in turn stimulate potential value creation in other sectors and industries, if executed properly, and initiate a pro-cyclical reinforcing cycle across sectors. Another example of chain-reactions is the data impact. If enough data is gathered and analyzed, then it can further describe necessities in the beginning of the supply chain, and further on create chain-reactions leading to change in consumer behavior, interest and awareness of circularity, and ultimately lead to a powerful up-stream shift in demand from end-users.

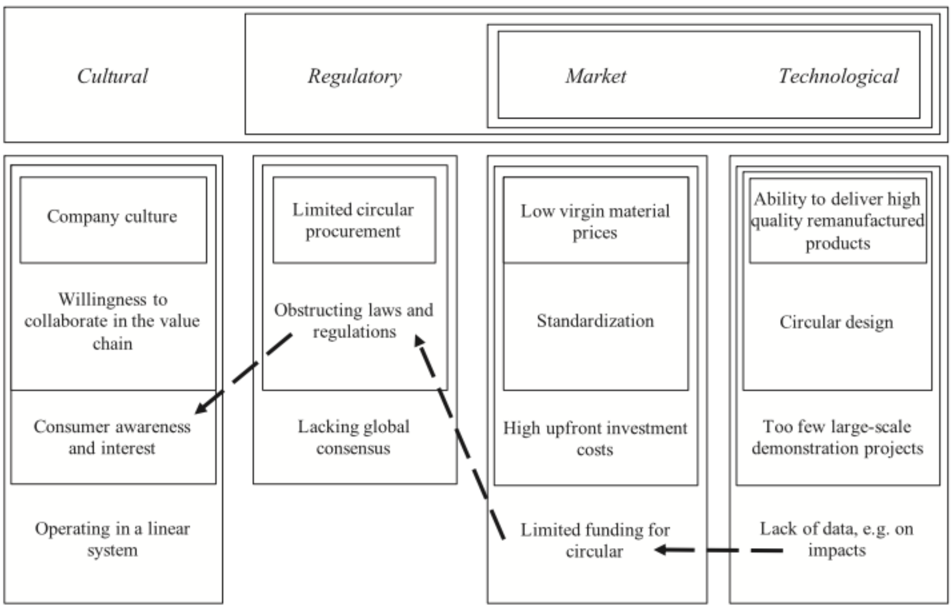

Figure 7: Barrier interrelatedness (Kirchherr et al., 2018).

4.3.2 Incentivization as Enabler Toward a Circular Economy

Regulatory barriers can for example induce economic/market barriers, and when economic incentives arise, it is only natural it can induce technological development in circular technological advancement. To illustrate how these spillover-effects may play out, an example of how a relaxation in regulatory barriers can have a pro-cyclical effect in the economic activity in the market is considered appropriate.

When a new regulatory barrier which is introduced, in this example a taxation relief in the reutilization and recycling of EVBs, then the subsidy may carry added value to the economic barriers. New industries and organizations may arise due to the tax relief, since there now is potential revenue to harvest from this opportunity. When the market becomes more competitive as there are profits available from multiple player entry, the competitiveness of the free-market forces in will subsequently pressure prices toward marginal costs. Technological innovation and utilization will followingly on incentivize increased efficiency in the operations, which in turn reduces the resource intensity and stimulates increased resource efficiency in the market as the new competitive advantage.

Another example can be that technological innovations reduces resource intensity, which may also deflate economic barriers in some sense. When resource intensity declines from an increase in efficiency, steady output is maintained, and economic activity and consumption will generally increase. Sub-categorical barriers such as willingness to collaborate throughout the value chain must also be facilitated as the capitalistic market-forces are primarily driven by the linear economy model. This requires substantial dedication across and in between players to obtain, and alone stand little chance for successful implementation. The interrelatedness of the categorical barriers may be a foundation in the market failing to adopting CE models, working as a degenerative reinforcing loop working as a chain reaction obstructing the market efficiency and theoretical optimal market progress toward a CE (Kirchherr et al., 2017).

4.3.3 The Scale Problem

Despite the scale of the infrastructure, most operations and economic behavior is still customized to a linear economy. However, this driver is a back-end (upstream) driver of the model, therefore without considerably meaningful restructuring in design and manufacturing of goods and services at the initial phase of the value chains, the potential will likely not ever reach a point of full circularity. The additional effort input in the disassembly and recycling of the end-of-cycle products could instead be applied to the design phase of the goods and services produced instead, making a considerable impact throughout the whole value chain due to the facilitation for circular products.

Due to the abovementioned examples and thorough assessment of barriers, the barrier that seems most prominent and influential in facilitating successful CE implementation is the regulatory and political barriers, which in turn create spillover-effects and can facilitate and enable opportunities to overcome the identified barriers. Regulatory and political barriers is considered a necessity for stimulating further development to implementation of CE models throughout economies, which increase the degree of interrelatedness and positive effects of the other barriers to CE. The idea is to identify triggers which pertain the possibility to create spill-over effects to other barriers and opening new opportunities such that the free-market forces come in play to further decompose and overcome the barriers.

4.3.4 End-user as enabler toward a Circular Economy

If consumers and end-users do not grasp an interest in circular alternatives, and therefore do not demand circular goods, then organisations will likely not produce circular-friendly goods and services profitably, following basic economic theory on supply and demand. This upstream demand from consumers is a major influential driver and enabler toward a circular economy. Therefore, increasing the level of knowledge and importance of circularity of consumers and end-users should be a priority by the government and policymakers (Kirchherr et al., 2017).

4.4 The Fundamental Theorems of Welfare Economics

4.4.1 Criticism and opposing views

Ever since Adam Smith formulated the outline for the fundamental theorems of welfare economics it has been used as a base for later economist, but it has also been prone to criticism and opposing views. The opposing arguments often points out the weakness of the laissez-faire conception. Claiming that a command economy[5] is superior to free-market mechanism that opposes government intervention, and that even if markets are competitive, the existence of external effects, public goods, information asymmetries, and other sources of market failure ensures that laissez-faire does not bring about the common good (Greenwald & Stiglitz, 1986). In addition, criticism suggest that markets are often monopolized in the absence of government intervention, obstructing the requirement of perfectly competitive markets.

The seven assumptions written in section 2.4, taken to achieve the general equilibrium through the fundamental theorems of welfare economics is only viable under ideal conditions, and full satisfaction of these conditions is not occurring in any actual economy (Perman et al., 2003). Making it so that the two theorems only hold in the presence of ideal conditions being assumed upon the economy. Thereby, most markets seem to fail in comparison to this theoretical idea, hence, not reaching an efficient allocation. Markets are typically in a situation with either excess supply or excess demand, implying that there are constant fluctuations due to the dynamic nature of the economy. The first theorem on the other hand assumes a fixed model, with no fluctuations or exposure of market power.

4.4.2 Circular Economy and The Fundamental Theorems of Economic Welfare

Economic efficiency or an efficient resource allocation occurs in the situation when there exists no other allocation that makes anyone better off without making someone else worse off, rooted in the notion of Pareto-optimality and welfare maximization. As mentioned previously, CE has its origins from IE and most of the encircling literature has not engaged in the neoclassical approach to efficiency (Bimpizas-Pinis et al., 2021). Furthermore, neoclassical economic models

[5] A command economy is a system where governments are responsible for coordination of directives, targets and regulations, as well as how and what should be produced in the economy at what price (Investopedia, 2021).

emphasize the utility of the environment for humans, measured in economic welfare, not accounting for the values rights of the environment (Andersen, 2007).

Environmental economics and sustainability issues introduce even more challenges for the well-grounded theorems of economic welfare. By exposing the theorems for the complex and diverse implications of environmental economics, questions of its validity get even more pressing. There are different contributions of the environmental problems that could lead to inefficiencies, or a case of market failure (Perman et al., 2003). The consequences of economic activity, excess supply, or excess demand, and over extraction of natural virgin resources lead to welfare losses, damages environmental quality and degrades bases of natural resources. Often divided into two categories of either emissions through air, water, soil or noise pollution, or environmental degradation of wildlife, wildland, biodiversity, or nonrenewable resources.

The development of the theorems as we know them prevailed in the 18th century onwards. The industrial revolution in the late 18th – mid 19th century launched the conveyor belts onto industrial processes. With resource extraction and inputs on one side and the environment as a waste bin on the other. This one-way production and consumption model marked the genesis of the LE and a continuous degradation of regenerative natural processes. In order to fulfill the "Sustainable Development" definition by the Brundtland Commission, consumption is required to stay constant. The implication is, in the absence of technological development, the definition also requires stock of natural resource availability to be kept constant (Andersen, 2007). The case of CE is about delivering a value proposition of reproduction rather than just measuring growth through improved efficiency and productivity. CBMs would focus on retaining the value of resources by keeping them in circulation through the economy. This approach to production and consumption is the polar opposite to the traditional LE. Therefore, economists need to rethink the application and validity of the fundamental theorems in relation to CE. In the next section we will assess the common sources of market failure and resource inefficiency in the presence of environmental problems.

4.4.3 Market Failure and Resource Efficiency

What is welfare, what is market failure, and what is the optimal Pareto outcome? Traditionally, economic welfare and growth is generally measured through GDP and GDP growth per capita. Let's break it down to illustrate what is in fact incorporated in GDP and what might be reluctant to be accounted for. GDP is defined as the total monetary value of all goods and services produced in an economy. This definition of GDP implies that the way we estimate and evaluate welfare is through the monetary value of the goods and services that are produced in the economy. So, what about social welfare and -standards? Gender equality, and well-being? What happens to economic development and progression when there are no more natural resources to utilize, the environmental impact is too severe for the planetary boundaries to uphold, and we have developed a major waste problem in the process? At this point in time, our economic system is not constructed or suited to neither provide an answer, nor solve the major challenges that we face.

"Resource allocation" or just "allocation" concerns what kind of goods are being produced and in what quantity, which combination of resource inputs are used in production, and how the output is distributed between consumers. Efficiency in allocation requires that three efficiency conditions are fulfilled – efficiency in consumption, efficiency in production, and product-mix efficiency. We have already established that markets are prone to fluctuations and subject of market power, which contradicts the fixed fundamental theorems. Furthermore, in environmental economics, pollution is considered a market failure generating externality. A missing market for the taxation of for example carbon emissions can lead to severe externalities and excess waste (Flachenecker & Rentschler, 2019). In the case of CE, political institutions should create a market for extraction of resources, and in particular scarce resources. Penalizing firms and production companies that continue feeding on virgin resources, and thereby providing an incentive to invest in circular solutions.

Market prices should reflect the external cost on the environment caused by the excessive over-extraction. In order to calculate the external cost estimates of the value of circular solutions are required as well as a "*quantification of the environmental consequences of marginal changes in economic activity*" (Andersen, 2007), preferably revealing individual preferences for circular goods. After the assessment of external costs, environmental taxes and charges can be introduced to market transactions, securing that the marginal cost of external cost is reflected in market prices (Andersen, 2007). The pull on the environment is then no longer a free commodity but has a corresponding price tag. The first theorem further assumes no existence of public goods. This is problematic since the effects of over-extraction of natural resources have negative effects on climate, biodiversity, water quality and clean air. Open access natural resources exhibit rivalry, but not excludability, meaning that no agent can be prevented from enjoying the resources unless it is subject to private property rights (Perman et al., 2003).

Moving on, the first theorem assumes away distribution effects. Laissez-faire and free-market capitalism without government intervention may produce a Pareto optimal outcome. The implication is that some agents have an initial endowment of resources even before any transaction have occurred. This calls for a situation with multiple Pareto optimal outcomes, where some prove to be fairer than others (Greenwald & Stiglitz, 1986; Sandmo, 2014). The distribution solution to this initial endowment problem brings theory over to the second welfare theorem with lump-sum taxes and transfers to compensate the agent who is worse off (Perman et al., 2003). The second theorem introduces governmental intervention through policies, competition law and regulation. An assessment by governments need to address how, who and if they should subsidize certain firms, will this consequently make someone else worse of. As we know, there is a risk involved of being the first mover, and a governmental subsidization might contribute to mitigate that risk. But how about those firms who were left without a subsidy and decided not to implement CBMs? In the long run, when the subsidized firms establish the new CBMs and individual preferences of consumers favor the circular goods, the firms of traditional LE will eventually be in a worse position than prior to the intervention.

If the market captures the resource scarcity along with the environmental impact and cost from the LE model, then theory would indicate that the market should incorporate these factors, and the market forces should provide an efficient outcome. So why does this not seem to be the case? Technological advancement may hold the key to conundrum. Technological development and -innovations are generally tools that can mitigate potential inefficiencies in collaboration with the free market forces. However, if we rely solely on this technological advancement to solve the climate challenges and believe that it can close the inefficiency gaps (output gap) through the market forces – then we will likely not reach the climate goals. The technology should be utilized together with regulatory and political subsidies and incentives to strengthen the impact they hold on to the environmental concerns. When operating within the planetary boundaries, resource efficiency should increase as a consequence of reutilization of primary resources, both reducing extraction as well as reducing residual waste. By incorporating the environment as a resource constraint into the economic model, it might be possible to escape from the degenerative economic model, and instead construct viable, sustainable, and long-term business models for the economy and resources to thrive in.

4.4.4 Resource Efficiency in the Electric Vehicle Industry

Today, EVs are considered more environmentally friendly than FFVs, however there are still some pollution sources from production of the EVBs and EVs that exceed that of the FFV. If an EV however runs on renewable energy sources, it takes approximately 2 years (Hall & Lutsey, 2018) until EVs have less negative impact on the environmental than FFVs. From the aspect of production, the EVBs require several scarce raw materials such as cobalt, lithium and mangan. If the EV demand grows at the expected rate, these resources will eventually run out and the market demand cannot be sated the way the market operates today. This challenge provides the opportunity to reutilize these raw materials from old EVBs, such that the already scarce resources can re-enter the cycle. This opportunity may diminish the environmental impact from extraction, as well as minimizing the problem of waste from toxins in the rare metals composed in the EVBs. This industry poses an opportunity for circular business models; as markets are soon facing a flood of dated EVBs, the opportunity of reuse, recycling and remanufacturing have been identified by several actors in both Norway and Europe. With an ambition of recycling up to 90% of the battery components, HydroVolt is aiming to increase efficiency and introduce circularity into the production of batteries of the future (Elbil24, 2021).

4.5 Network Effects and Circular Business Models

In light of the knowledge we have gained on network effects and circular economy business models, we will in this section discuss how these can cooperate to challenge existing business models. Applying network effects to create any circular business model, and in particular to the EV industry, is no straightforward exercise. The concept of network effects has emerged alongside with the technological advancement over the last decades. Therefore, it is only natural that the concept is characterized by IT products and different internet platforms, such as social media and e-commerce. However, we believe the theory and logic can be applied to other markets and circular business models in general. Merging network effects and CE might influence buying decisions of agents, marketing strategies of competing vendors, supply and demand equilibria, and have implications on welfare fundamentals (Weitzel et al., 2000).

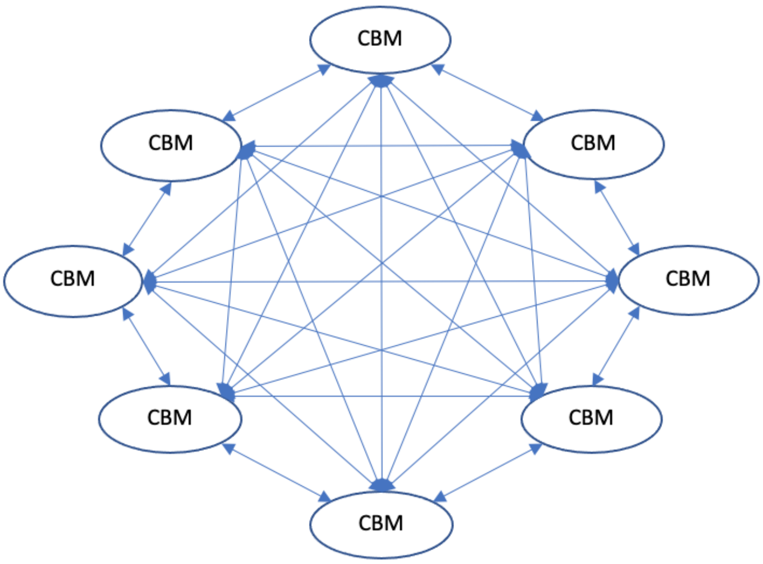

Figure 8: Theorizing CBMs in a Circular Economy

The three issues of network competition brought forth by Katz and Shapiro (1994) can provide some insight to the challenge. As the CE is "r*estorative or regenerative by intention and design*" (Ellen MacArthur Foundation, 2013), this implies that components will circulate in economy for longer through either reuse, remanufacturing or recycling. In turn, this could be beneficial for the rational buyers to form expectations of the availability and quality of components needed for future investments. Once circularity has taken hold in markets and the hardware-software paradigm, network effects can contribute to increase trust and connectedness to the CBM (Lahti et al., 2018), creating a lock-in relationship with consumers and agents. Furthermore, the circular and restorative nature of the market will offer a wide availability of components, and thus be a popular choice to invest in. Katz and Shapiro (1994) argue that the positive-feedback effects in a scenario like this is disrupting economic theory, both in terms of the fundamental theorems of economic welfare and market performance, and to technical equilibrium concepts.

The second issue is of coordination arise as it is costly to establish an infrastructure for circularity and CBMs. Both network effects and CE encourages entrepreneurs and businesses to pursue unique and effective solutions. However, uncertainty of profitability and return on investment prevents adoption as no actor is willing to bear the risk of being the first mover towards a new standard. For instance, there is no incentive to design and produce sustainable and circular goods if there is no system for collection, recycling or remanufacturing as the two complements each other. The CE suggests a closed-loop design of value chains, this requires organizing and coordinating of entire value chains, from bottom tier suppliers to the regenerative step of the chain. The vast global value chains of today have transformed into networks, and to achieve circularity in this web of suppliers and consumers requires investment in all parties involved (Lahti et al., 2018). The pressure to make given investments must either come from governmental regulation and requirements of more sustainable operations or contracted by large firms constraining their suppliers to conduct production in a circular fashion (Lahti et al., 2018). As more agents are adopting CBMs, the extended life and use of resources are beneficial for sustainability and economic stability.

The issue of compatibility is one that discusses if a component is designed to work in one system or for one product, could it then also be used in other systems. The term “standardization” is mentioned in the concept of CE, as a standardized product would be the most efficient solution when goods reach end-of-life and recycling, or remanufacturing is the next option. This could be important to form common protocols on smart infrastructure and the replaceability of parts (Preston, 2012). Other the other hand, compatibility and standardization could involve a sacrifice in innovation and variety of developments in technology. The question really is, what institutions or firms can effectively induce more users to join a network of CBMs, and who will invest in the expansion of such a network?

The transition to - or adoption of CBMs require innovation by either replacing existing business models or seize new opportunities for improvement. By leveraging their scale and creating a strategy for network effects and circularity, companies with significant market shares and complex vertical value chains can contribute significantly in the transition to CBMs and CE. Alongside with entrepreneurial developments in effective and efficient solutions, profitable CBMs will inspire and in some case contractually bind other organizations and suppliers to expand into the transition (Ellen MacArthur Foundation, n.d).

4.5.1 Network Effects and Multiple Equilibrium Outcomes

Another term used for network effects is *demand-side economies of scale* (Shapiro & Varian, 1999). The positive feedback loop and the increased perceived value of the service or commodity alters the characteristics of the demand curve. From microeconomic theory, the demand curve is typically a downward sloping function of the price. The altered dynamics and impact of network effects, or demand-side economies of scale, impose a set of changes to the traditional demand curve, which in turn affects the formulation of market equilibriums. Shapiro & Varian (1999) propose a model which show that in a market that exhibits network effects, the total value of a good or service depends on both the intrinsic value and the number of people purchasing the same product. Rohlfs (1974) suggested the model *uniform calling pattern* where the number of subscribers affects the value of the service, which resulted in an inverted U-shaped demand curve, depicted in figure 10. Assuming that the market is characterized by perfect competition, then price of goods and services equals marginal costs. Depending on the size of the marginal costs, Rohlfs argues that this type of market consists of either none or multiple equilibria.

The interpretation of these equilibria is of particular interest in our assessment. As the user fraction rise from the stable equilibrium at the origin, the price and value increase exponentially towards point E, which is the intersection between the upward-sloping demand curve and the marginal cost. This point is considered as an unstable equilibrium, and according to Rohlfs, it is also interpreted as the point of "critical mass". Once a market reaches this point, the network effects become more self-sufficient, and the user fraction rapidly increases to the stable equilibrium in point B. At this point the demand curve is more familiar with its downward-sloping appearance and gives the maximum level of demand sustainable at a given price. However, if the user base never reaches the point of critical mass, it will rapidly descend back to zero at the origin.

The first issue of expectations by Katz & Shapiro (1985) discussed in section 4.5 above is essential in asserting the possible equilibrium outcomes. Agents are rational, and economic decisions are taken based on expectation about the future development in the market. Fulfilled expectations about the future development of CE and CBM can therefore depict how many participants who are engaging in a transition, and which of the three equilibria the market is achieving.

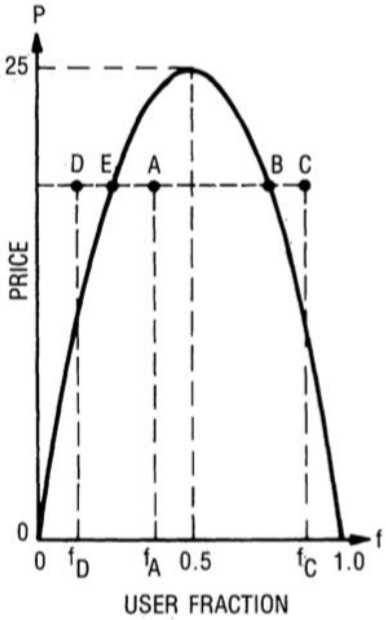

Figure 9: Demand Curve for Uniform Calling Pattern (Rohlfs, 1974).

4.5.2 The Case of Electric Vehicles, Network Effects and Circular Business Models

The EV industry have certain similarities and characteristics familiar to network effects and circularity. Take the indirect network effect and the hardware-software paradigm, an agent who is in the market for an EV would be concerned with the number of other agents purchasing similar EVs, because of the amount and variety of charges that will be supplied is a function of how many EVs that have been sold. No one would produce and install chargers if no one were purchasing EVs, and vice versa, no one would buy EVs if there are no chargers. While the direct network effect of more firms adopting CBMs would be the reduced negative environmental footprint as more firms jump onboard.

In cases like this, there is need for some initial incentive to kick-off the transition. In Norway the government incentivized consumers by allowing access to bus lanes, lower fees, and taxation, as well as electricity is cheaper than fossil fuel. When the incentives surpass the marginal willingness to adopt the EV in terms of utilization and costs, then EVs started gaining traction in the market, and reaching its critical mass per se.

5 Concluding Remarks

The CE inherits great potential to solve many of the concerns provided by the LE model. In the transition to a CE, we must strategically change our habits and behavior – both regarding consumption and our general economic decisions. The CE aims to reduce consumption, and reuse, recycle and repair goods and services such that the resources' lifetime is both extended, and re-enters into a new life cycle based on recycled and remanufactured virgin resources. The model incorporates the planetary boundaries provided by the earth, stabilizing the economy through a delicate balance rather than challenges provided by the LE.

To reach a level of circularity in the economy such that the CE becomes regenerative and self-sufficient, overcoming several categorical barriers are essential to the viability of the economic model. The barriers inherit some degree of interrelatedness in a way such that inducing tangible incentives and subsidies will to some extent allow for chain-reactions to other barriers and sub-categorical barriers. The most essential however, is the ability to remove or overcome all the barriers to allow for a global reach of the CE and a degree of full circularity. This can be obtained in theory by identifying triggers to the chain reactions across the barriers to stimulate further self-sufficiency of the economic model. Enough empirical studies have yet not been published such that we can conclude whether it is practically feasible as indicated by economic theory.

The fundamental theorems of welfare economics emerged along with the first industrial revolution in the transition between the 18th and the 19th century, which subsequently launched mass production processes with LE characteristics. The concerns of environmental - and sustainability issues developed over the last decades have challenged the well-grounded theorems. By inflicting planetary boundaries, resource constraints and different sources of externalities upon the efficiency mechanism of the theorems, it proves challenging to fulfill the theoretical Pareto efficient allocation. Even the more flexible mechanism of distribution by governmental intervention in the second welfare theorem impose a set of implications when deciding which efficient outcome is optimal for the economy. For a potential optimal outcome to be achieved, market prices should reflect the external cost on the environment caused by the excessive over-extraction, and preferably reveal individual preferences for circular goods.

Once an incentive scheme and a plan for subsidization of CE and CBMs is in place, it is essential that governments and organizations make effective decisions on how to coordinate the implementation of this new structure, provide directive standards for compatibility of goods, and make sure that market agents are informed about the future potential and development of CE goods and services. This will strengthen the network effect and contribute to reaching critical mass and self-sufficiency for CBMs.

The EV industry in Norway is an example of how policymakers can in fact identify strategic triggers to stimulate the market. When the free-market forces gain sufficient traction, it will further on provide an efficient market following the incentives given by the policymakers. An example is that the demand for EVs were not particularly high before there were inferred any economic incentives and sufficient infrastructure ensuring mobility in the market. When there is little demand in a market, no agents and organisations will provide goods or services as long as the market is not sufficiently profitable. However, when economic incentives are induced, such as 50% tax relief on purchasing an EV in Norway, the demand increases, and the market forces facilitates and ensures a stable and efficient market outcome, building on the circularity and sustainable mindset from the CE model.

In conclusion, the CE model seems to fit traditional economics moderately. On one hand it is a disruptive economic model in the sense that it reconstructs the foundational economics which has been leading for centuries, incorporating planetary boundaries and environmental concerns as constraints to address and adjust for modern challenges. On the other hand, it maintains value creation and economic growth possibilities such as the LE model and uses the same primary economic indicator, namely growth in GDP and measures welfare through monetary values. In summation, the CE is disrupting and modernizing traditional economics. It is well suited to address modern challenges and concerns and uses the LE as a revising tool to construct a more modern and time-appropriate economic model for the 21st century.

5.1 Suggestions for further research

For future research on the field of CE and modern economics, the authors recommend that further research should be on a fiscal transition toward a CE, in a way such that it enlightens policymakers and the general public to require more circular goods and services for a concrete target model, in a similar fashion to how the UN's SGDs were developed. The impact of technological development and policymakers' legislations on the transition toward the CE is also recommended to be further researched, as it portrays an impact factor able to induce the transition.

Extending the scope, further research on Doughnut Economics is also encouraged. The reason being that the CE directly address the most pressing concerns provided by the LE, however, it does not aim to change and modernize the overall goal of the model. Economic growth and development in GDP as indicators for welfare seem to have a date of expiry after the CE model has been globally incorporated. Doughnut Economics utilize the framework from the CE model, and further address how we evaluate welfare, which in time should include social welfare and general well-being as indicators in addition to economic welfare.

6 References

Andersen, M. S. (2007). An introductory note on the environmental economics of the circular economy. *Sustainability Science*, *2*(1), 133–140. https://doi.org/10.1007/s11625-006-0013-6

Andrew, B. (2008). Market failure, government failure and externalities in climate change mitigation: The case for a carbon tax. *THE CASE FOR A CARBON TAX*, 9.

Argue, C. (2020, July 7). *What 6000 electric vehicles tell us about EV battery health?* Geotab. https://www.geotab.com/blog/ev-battery-health/

Bimpizas-Pinis, M., Bozhinovska, E., Genovese, A., Lowe, B., Pansera, M., Alberich, J. P., & Ramezankhani, M. J. (2021). Is efficiency enough for circular economy? *Resources, Conservation and Recycling*, *167*, 105399. https://doi.org/10.1016/j.resconrec.2021.105399

Bjerke Soldal, O. (2021, May 3). *Økonomien må lære av økologien*. BI Business Review. https://www.bi.no/forskning/business-review/articles/2021/05/okonomien-ma-lare-fra-okologien/

Boulding, K. E. (1966). *The Economics of the Coming Spaceship Earth*. https://www.bivalue.at/pics/Boulding_SpaceshipEarth.pdf

Boulding, K. E. (1971). After Samuelson, Who Needs Adam Smith? *History of Political Economy*, 13.

Boye, E. (2019). *Sirkulær framtid—Om skiftet fra lineær til sirkulær økonomi* (p. 59). Framtiden i våre hender. https://www.framtiden.no/aktuelle-rapporter/874-sirkulaer-framtid-om-skiftet-fra-lineaer-til-sirkulaer-okonomi/file.html

Bruel, A., Kronenberg, J., Trossier, N., & Guillaume, B. (2018). *Linking Industrial Ecology and Ecological Economics: A Theoretical and*

Empirical Foundation for the Circular Economy. 10. https://doi.org/10.1111/jiec.12745

Circular Norway. (2020). *The Circularity Gap Report Norway* (No. 1; p. 82). Circular Norway. https://de312f73-4ba4-4a83-b0e6-01dc20f54c34.filesusr.com/ugd/8853d3_4878d746a9fc40f0a9aacd113e090abc.pdf

Climate Change Committee. (n.d). *A Natural Climate Cycle*. The Science and Impacts of Climate Change. https://www.theccc.org.uk/the-science-of-climate-change/climate-variations-natural-and-human-factors/a-natural-climate-cycle/

Deloitte. (2020). *Kunnskapsgrunnlag for nasjonal strategi for sirkulær økonomi—Delutredning 2*. Regjeringen. https://www.regjeringen.no/contentassets/7ca1a81f57cc4611a193570e80c4dafd/deloitte_kunnskapsgrunnlag-sirkular-okonomi_barrierer.-delrapport-2.pdf

Denchak, M. (2017, February 23). *Global Climate Change: What You Need To Know* [NRDC]. https://www.nrdc.org/stories/global-climate-change-what-you-need-know

Elbil24. (2021, January 10). *Skal gjenvinne minst 90 prosent*. Gjenvinning av elbilbatteri. https://www.elbil24.no/nyttig/skal-gjenvinne-minst-90-prosent/73255996

Ellen MacArthur Foundation. (2013). *Towards the circular economy: Economic and business rationale for an accelerated transition* (p. 96). Ellen MacArthur Foundation. https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf

Ellen MacArthur Foundation. (n.d). *Building blocks*. https://www.ellenmacarthurfoundation.org/circular-economy/concept/building-blocks

European Commission. (2020a). A new Circular Economy Action Plan. *European Comission*, 19.

European Commission. (2020b). *Circular Economy Action Plan*. European Comission. https://ec.europa.eu/environment/pdf/circular-economy/new_circular_economy_action_plan.pdf

European Commission. (2020c). *Green deal: Sustainable batteries for a circular and climate neutral economy* [Press release]. https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2312

Flachenecker, F., & Rentschler, J. (2019). *From barriers to opportunities: Enabling investments in resource efficiency for sustainable development*. 29. https://doi.org/10.3326/pse.43.4.2

Grafström, J., & Aasma, S. (2021). Breaking circular economy barriers. *Journal of Cleaner Production*, *292*, 126002. https://doi.org/10.1016/j.jclepro.2021.126002

Greenwald, B. C., & Stiglitz, J. E. (1986). Externalities in Economies with Imperfect Information and Incomplete Markets. *Oxford University Press*, *101*(1), 37.

Hall, D., & Lutsey, N. (2018). *Effects of battery manufacturing on electric vehicle life-cycle greenhouse gas emissions* (p. 12). The International Council on Clean Transportation. https://theicct.org/sites/default/files/publications/EV-life-cycle-GHG_ICCT-Briefing_09022018_vF.pdf

Hamilton, J., Walton, B., Ringrow, J., Alberts, G., Fullerton-Smith, S., & Day, E. (2020). *Electric vehicles*. Deloitte.

Investopedia. (2021, April 19). *Command Economy*. Government and Policy. https://www.investopedia.com/terms/c/command-economy.asp

IPCC. (2015). *Climate change 2014: Synthesis report* (p. 151). Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

Kagan, J. (2020, April 28). *Pigovian tax* [Investopedia]. https://www.investopedia.com/terms/p/pigoviantax.asp

Katz, M. L., & Shapiro, C. (1985). Network Externalities, Competition, and Compatibility. *American Economic Association*, *75*(3), 18.

Katz, M. L., & Shapiro, C. (1994). Systems Competition and Network Effects. *American Economic Association*, *8*(2), 85.

Kirchherr, J., Hekkert, M., Bour, R., Huibrechtse-Truijens, A., Kostense-Smit, E., & Muller, J. (2017). *Breaking the Barriers to the Circular Economy [White paper]* (p. 13). Deliotte. https://circulareconomy.europa.eu/platform/sites/default/files/171106_white_paper_breaking_the_barriers_to_the_circular_economy_white_paper_vweb-14021.pdf

Kirchherr, J., Piscicelli, L., Bour, R., Kostense-Smit, E., Muller, J., Huibrechtse-Truijens, A., & Hekkert, M. (2018). Barriers to the Circular Economy: Evidence From the European Union (EU). *Ecological Economics*, 9. https://doi.org/10.1016/j.ecolecon.2018.04.028

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular Economy: The Concept and its Limitations. *Ecological Economics*, *143*, 37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041

Lahti, T., Wincent, J., & Parida, V. (2018). A Definition and Theoretical Review of the Circular Economy, Value Creation, and Sustainable Business Models: Where Are We Now and Where Should Research Move in the Future? *Sustainability*, *10*(8), 2799. https://doi.org/10.3390/su10082799

Majumdar, S. K., & Venkataraman, S. (1998). Network effects and the adoption of new technology: Evidence from the U.S. telecommunications industry. *Strategic Management Journal*, *19*(11), 18. https://doi.org/10.1002/(SICI)1097-0266(1998110)19:11<1045::AID-SMJ990>3.0.CO;2-0

Meld. St. 20. (2021). *Nasjonal transportplan 2022-2030* (p. 261). Samferdseldepartementet. https://www.regjeringen.no/contentassets/fab417af0b8e4b5694591450f7dc6969/no/pdfs/stm202020210020000dddpdfs.pdf

Meld.St.13. (2021). *Klimaplan for 2021-2030*. Klima- og miljødepartementet. https://www.regjeringen.no/contentassets/a78ecf5ad2344fa5ae4a394412ef8975/nn-no/pdfs/stm202020210013000dddpdfs.pdf

Melin, H. E. (2018). The lithium-ion battery end-of-life market—A Baseline Study. *World Economic Forum*, *2018*, 1–11.

Miljødepartementet. (2020). *Update on Norway's nationally determined contribution*. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Norway%20First/Norway_updatedNDC_2020%20(Updated%20submission).pdf

Miljødirektoratet. (2020a). *Klimakur 2030* (M–1625; p. 1196). https://www.miljodirektoratet.no/globalassets/publikasjoner/m1625/m1625_sammendrag.pdf

Miljødirektoratet. (2020b, November 23). *Klimagassutslipp fra transport*. https://miljostatus.miljodirektoratet.no/tema/klima/norske-utslipp-av-klimagasser/klimagassutslipp-fra-transport/

Moser, S. C. (2010). Communicating climate change: History, challenges, process and future directions. *WIREs Climate Change*, *1*(1), 31–53. https://doi.org/10.1002/wcc.11

NASA. (2021). *Overview: Weather, Global Warming and Climate Change*. Global Warming vs. Climate Change. https://climate.nasa.gov/resources/global-warming-vs-climate-change/

Niese, N., Pieper, C., Arora, A., & Xie, A. (2020). The Case for a Circular Economy in Electric Vehicle Batteries. *Boston Consulting Group*, 22.

Nordhaus, W. (2007). *The Challenge of Global Warming: Economic Models and Environmental Policy*. Yale University. https://grist.org/wp-content/uploads/2007/12/dice_mss_091107_public.pdf

Norsk Elbilforening. (n.d). *Norwegian EV policy*. https://elbil.no/english/norwegian-ev-policy/

OECD. (2020). *Beyond Growth: Towards a New Economic Approach* (New Approaches to Economic Challenges). OECD. https://doi.org/10.1787/33a25ba3-en

Perman, R., Ma, Y., McGilvray, J., & Common, M. (2003). *Natural resource and environmental economics* (3. ed., [Nachdr.]). Pearson Addison Wesley.

Preston, F. (2012). *A Global Redesign? Shaping the Circular Economy*. 20.

Raworth, K. (2017). Why it's time for Doughnut Economics. *IPPR Progressive Review*, *24*(3), 216–222.

Ritchie, H. (2020, September 18). *Sector by sector: Where do global greenhouse gas emissions come from?* [Org]. Our World in Data. https://ourworldindata.org/ghg-emissions-by-sector

Rizos, V., Behrens, A., Kafyeke, T., Hirschnitz-Garbers, M., & Ioannou, A. (2015). The Circular Economy: Barriers and Opportunities for SMEs [Working document]. *CEPS*, 26.

Rohlfs, J. (1974). A Theory of Interdependent Demand for a Communications Service. *The Bell Journal of Economics and Management Science*, *5*(1), 16. https://doi.org/10.2307/3003090

Samferdselsdepartementet. (2021, June 10). *Norge er elektrisk* [Regjeringen]. https://www.regjeringen.no/no/tema/transport-og-kommunikasjon/veg_og_vegtrafikk/faktaartikler-vei-og-ts/norge-er-elektrisk/id2677481/

Sandmo, A. (2014). Adam Smith and Modern Economics. *NHH Institutt for Samfunnsøkonomi*, 22.

Sariatli, F. (2017). Linear Economy versus Circular Economy: A comparative and analyzer study for Optimization of Economy for Sustainability. *Visegrad Journal on Bioeconomy and Sustainable Development*, *6*(1), 4.

Shapiro, C., & Varian, H. R. (1999). *Information rules: A strategic guide to the network economy*. Harvard Business School Press.

SINTEF. (2020). *Studie av potensialet for verdiskaping og sysselsetting av sirkulærøkonomiske tiltak* (2020:00958). SINTEF. https://sintef.brage.unit.no/sintef-xmlui/bitstream/handle/11250/2690052/2020_00958%2bStudie%2bav%2 bpotensialet%2bfor%2bverdiskaping%2bog%2bsysselsetting%2bav%2bsirkul%25C3%25A6r%25C3%25B8konomiske%2btiltak.pdf?sequence=1&isAllowed=y

Siqi, Z., Guangming, L., Wenzhi, H., Juwen, H., & Haochen, Z. (2019). Recovery methods and regulation status of waste lithium-ion batteries in China: A mini review. *Waste Management*, 11.

Stigler, G. J. (1958). The Economies of Scale. *The Journal of Law and Economics*, *1*, 54–71. https://doi.org/10.1086/466541

Stiglitz, J. E. (1987). PARETO EFFICIENT AND OPTIMAL TAXATION AND THE NEW NEW WELFARE ECONOMICS [Working paper]. *National Bureau of Economic Research*, *2189*, 69. https://doi.org/10.1016/S1573-4420(87)80010-1

Stiglitz, J. E. (1991). *The Invisible Hand and Modern Welfare Economics* (No. w3641; p. w3641). National Bureau of Economic Research. https://doi.org/10.3386/w3641

The Explorer. (2021, February 22). *Building a circular battery economy in Norway*. https://www.theexplorer.no/stories/energy/building-a-circular-battery-economy-in-norway/

United Nations. (2015). *The Global Goals*. globalgoals.org

United Nations. (n.da). *Goal 13: Take urgent action to combat climate change and its impacts*. Sustainable Development Goals. https://www.un.org/sustainabledevelopment/climate-change/

United Nations. (n.db). *The Paris Agreement*. United Nations Climate Change. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

Valstad, I., Grooss Viddal, M., Blindheim, K., H. Hersleth, H., Øren, K., & B. Lossius, T. (2020). *Norske muligheter i Grønne elektriske verdikjeder*. Styringskomiteen for Grønne Elektriske Verdikjeder. https://www.nho.no/siteassets/prosjekter-og-samarbeid/gronne-elektriske-verdikjeder.pdf

van Ewijk, S. (2018). *Resource efficiency and the circular economy* (p. 21). UCL Institute for Sustainable Resources. https://www.researchgate.net/profile/Stijn-Van-Ewijk/publication/327868697_Resource_efficiency_and_the_circular_economy_Concepts_economic_benefits_barriers_and_policies/links/5baa5cbaa6fdccd3cb730174/Resource-efficiency-and-the-circular-economy-Concepts-economic-benefits-barriers-and-policies.pdf

Varian, H. R. (2020). *Intermediate Microeconomics with calculus* (1 ed). W.W. Norton & Company.

Walmsley, T. G., Ong, B. H. Y., Klemeš, J. J., Tan, R. R., & Varbanov, P. S. (2019). Circular Integration of processes, industries, and economies. *Renewable and Sustainable Energy Reviews*, *107*, 507–515. https://doi.org/10.1016/j.rser.2019.03.039

Weitzel, T., Wendt, O., & Westarp, F. V. (2000). Reconsidering Network Effect Theory. *Association on Information Systems*, 9.

World Comission on Environment and Development. (1987). *Our Common Future*. Oxford University Press. https://sustainabledevelopment.un.org/content/documents/5987our-common-future.pdf