Norges miljø- og
biovitenskapelige
universitet

Master's Thesis 2016 30 ECTS
Department of Mathematical Sciences and Technology (IMT)

A Necessary Change – Suitable Policy Tools for the Transition into a Circular Economy

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Acknowledgments

This master thesis represents my culmination of five fantastic years of study at the Industrial Economics and Technology Management Programme at The Norwegian University of Life Sciences (NMBU).

I would like to thank all the people that have contributed to the fulfilment of this thesis. I would also like to thank all my friends and colleagues at NMBU for contributing to such a friendly and collaborative environment. The last five years have gone by so quickly, but I will not forget the good atmosphere and all the good discussions and teamwork we have had through the years.

"A human being is part of a whole, called by us the 'Universe' —a part limited in time and space. He experiences himself, his thoughts and feelings, as something separated from the rest—a kind of optical delusion of his consciousness. This delusion is a kind of prison for us, restricting us to our personal desires and to affection for a few persons nearest us. Our task must be to free ourselves from this prison by widening our circles of compassion to embrace all living creatures and the whole of nature in its beauty."

Albert Einstein

Abstract

Our current production system remains unsustainable and will eventually deplete virgin materials. There have been several efforts to make production more sustainable, e.g. different policy programs from governments that have tried to increase recycling, such as Extended Producer Responsibility (ERP) initiatives. This thesis states that these initiatives have not been enough to enable the development of a circular production system, as envisioned by the Circular Economy framework. The general effect of other policies and practices, such as Product Stewardship (PS), taxes on virgin materials, eco-design, deposit-refund systems and waste management are also assessed, in order to answer the research question: What are suitable policy tools that can support an effective strategy for a transition into a circular production economy?

Results form the analysis show that the use of a tax on virgin materials is the most promising alternative, but that this tax must be combined with supporting policies that increases consumer participation and recycling of feedstock materials, in order to be effective in the development of circular production. The use of subsidies is often necessary in order to strengthen the market share of new technologies such as renewable energy, but these subsidies should be used with caution to avoid the onset of "the green paradox". Policy tools in general should be used with caution, as they can cause market distortions and inefficiencies. They must have a clearly and narrowly defined goal in order to reach their desired effect; if the ambition of the policy tool is to widely defined, it will be very difficult to measure its effect. Additionally, there will be need for waste management systems that are effective in handling an increasing amount of waste globally, but at the same time does not create barriers for the establishment of circular production.

A creative approach and the use of economy and mathematical tools has resulted in the introduction of the "Earthsaver Tax Function" (ETF), the Adjusted Tax Rate and the Product Cycle, in which customers return materials for recycling to feed the circular production loop. The ETF is highly adjustable, and can be used to replace virgin materials with renewable materials, by using the tax as a feedback mechanism that funds the development of the renewable material.

Sammendrag

Vårt nåværende produksjonssystem er ikke bærekraftig, og kommer etter hvert til å utarme jordens råmaterialressurser. Det har vært flere forsøk på å gjøre produksjonen mer bærekraftig, blant annet ulike politiske programmer fra regjeringer som har forsøkt å øke gjenvinningen, f.eks. utvidet produsentansvar (ERP). Denne masteroppgaven hevder at disse tiltakene ikke har gjort nok for å tilrettelegge for utviklingen av et sirkulært produksjonssystem innenfor "Circular Economy" rammeverket. Den generelle effekten av andre retningslinjer og praksiser, for eksempel Product Stewardship (PS), skatt på råmaterialer, øko-design, pantesystemer og avfallshåndtering vurderes også, for å kunne svare på problemstillingen: Hva er egnede virkemidler som kan støtte en effektiv strategi for en overgang til en sirkulær produksjonsøkonomi?

Resultatene fra analysen viser at bruk av en skatt på råmaterialer er det mest lovende alternativet, men at denne skatten må kombineres med støttetiltak som øker forbrukernes deltakelse og resirkulering av råmaterialer, for å være effektive i utviklingen av sirkulær produksjon. Bruken av subsidier er ofte nødvendig for å styrke markedsandelen til nye teknologier, som fornybar energi, men disse subsidiene bør brukes varsomt for å unngå å sette i gang "det grønne paradoks". Politiske virkemidler generelt bør brukes med forsiktighet, da de kan forårsake konkurransevridning og ineffektiviteter i markedet. De må ha et klart og snevert definert mål for å oppnå ønsket effekt; hvis ambisjonen for virkemiddelet er for vidt definert, vil det være svært vanskelig å måle effekten. I tillegg vil det være behov for avfallssystemer som er effektive i å håndtere en økende mengde avfall globalt, men samtidig ikke skaper hindringer for etablering av sirkulær produksjon.

En kreativ bruk av økonomi og utvikling av matematiske verktøy har resultert i "Earthsaver Tax-funksjonen" (ETF), den justerte skattesatsen og produktsyklusen, der kundene leverer tilbake materialer til gjenbruk for å mate den sirkulære produksjonen. ETF er svært justerbar, og kan brukes til å erstatte råmaterialer med fornybare materialer, ved hjelp av skatt på råmaterialer som finansierer utviklingen av fornybare materialer.

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Acronyms and Abbreviations

CE – Circular Economy

DfE – Design for Environment

EPR – Extended Producer Responsibility

GDP – Gross domestic product

GHG – Greenhouse Gas

HDPE - High density polyethylene

IEA – International Energy Agency

IPP - Integrated product policy

ISWA – International Solid Waste Association

MSW – Municipal Solid Waste

MWTT – Modern Waste Treatment Technology

NOPAT – Net Operating Profit After Tax

OECD – Organization for Economic Cooperation and Development

PRO – Producer Responsibility Organisation

R&D – Research and Development

UNEP – United Nations Environment Programme

WEEE – Waste electrical and electronic equipment

WMC – Waste Management Company

Introduction

Next year, 2017, marks the 30-year anniversary for the release of "Our Common Future", the highly influential report from the Brundtland Commission (Our Common Future 1987), yet we are still nowhere near a sustainable global production economy. There have been several efforts, such as improved waste management, recycling and policy programs such as Extended Producer Responsibility (EPR) and recently the revival of the concept of the Circular Economy, but economic principles are still concentrated around cost-effectiveness and maximizing profits from production. If we are to achieve genuine progress in achieving sustainable production, we need to implement resource recovery targets that are aligned with a circular production economy. This will eventually lead to a much more sustainable and stable production economy. This study is therefore a contribution to the realization of a Circular Economy.

Why is this relevant?

Our production economy generates waste on an unprecedented scale. 8 million tons of plastic ends up in the ocean each year (National Geographic 2015).
The world is in dire need of better waste management, and it is our duty to act now. People and governments often view waste as a burden, when it should be viewed as an asset. Waste consists of several valuable materials, that should be used and reused, to extract the value and make sure that the materials does not disturb and pollute our ecological environment. This will create jobs and revenue for governments and private companies. In this way, waste management services can directly reduce poverty and harm to the environment in developing countries. The world will soon be drowning in waste, and we need to take responsibility for it. This thesis will include a short discussion on what the best solution is for developing countries that have poor waste management, and at the same time wants to transition into circular production.

The global production of waste is growing fast (see figure 1), both because the worlds population is growing, but also because many countries are developing economically, which means that people get wealthier, consume more and produce more waste. This is one of the reasons for the high projected growth in MSW per capita in Sub-Saharan Africa. However, as we can see from the figure below, the projection for high-income countries and OECD is declining MSW generation.

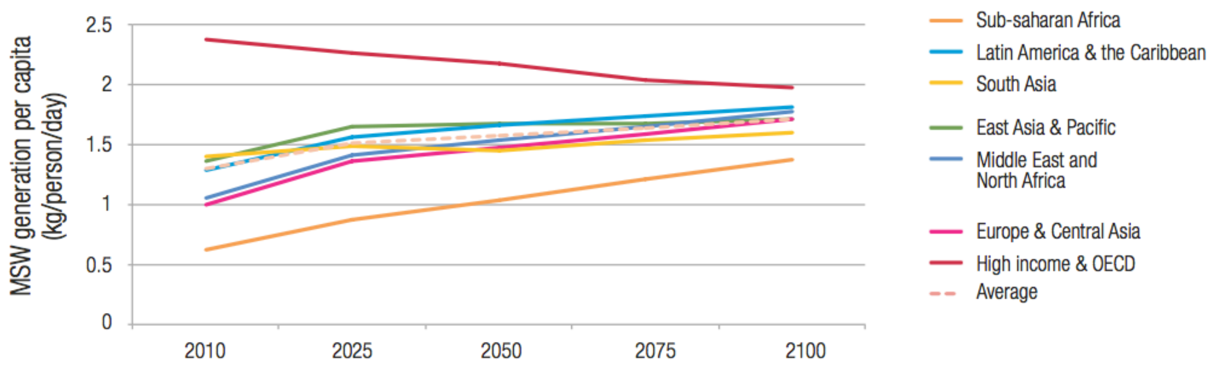


Figure 1. Projection for MSW generation per capita, GWMO, UNEP/ISWA, 2014.

The Washington Post writes in an article that if this growth continues without being addressed, there will be more plastic than fish in the ocean by 2050 (Washington Post 2016). Many countries, particularly developing ones, struggle to cope with the waste, and unable to establish proper waste management, the landfills are growing, and dumping sites are turning into enormous and often, toxic, mountains.

Dumpsites such as Payatas in the Philippines, the K'ara K'ara dump site in Cochabamba, Bolivia and the Duquesa dump site in the Dominican Republic are just a few examples of many, and clearly shows our failure to treat resources responsibly. The Estrutural dump site in Brazils capital, Brasilia, covers an area of 136 hectares, which is the equivalent of 194 football pitches (The Guardian, 2014).

These dump sites often provide an income to scavengers, who risk their health in order to survive. It is important to integrate these people in the development of waste management systems if they want to, and not just take away their livelihood. This can have dire social consequences. In Payatas they have managed to hire 3000 scavengers to work for the Payatas Alliance Recycling Exchange, but this was introduced as a measure to establish peace and stability in the former socially turbulent dumpsite. It also followed the tragic collapse in the dumpsite in the year 2000, when 300 scavengers where killed (The Guardian 2013).

It is also common in many developing countries that a lot of the waste is not being collected, leading to open burning of the waste or illegal dumping in rivers, oceans and forest areas by the public. This poses a serious health threat to both humans and animals and is very damaging to our ecosystem. Burning of waste with diesel creates hazardous fumes and increases the risks of forest fires. Dumping of mixed waste in nature leads to the creation of leachate, which can be very harmful to the ecosystem, by polluting groundwater and the soil.

The establishment of modern waste treatment technology (MWTT) is very important to gain control over the growing waste streams, but at the same time we need to change our production system, specifically by changing as much of the sourcing of materials from virgin materials to renewable materials as possible. This is important, because we are rapidly depleting many of our raw materials, and a huge amount of them end up in dumpsites. This requires a significant increase in the research on how to recycle materials, and how to make renewable materials that can be used for a wide array of products. While this system is being implemented we need to establish MWTT that does not compromise the system, or create economic and social barriers for the further use of renewable materials.

One way to speed up this development is to put more pressure on producers and consumers to take responsibility for their production and returning of waste back for recycling, respectively. This can be done by introducing a tax system on the use of virgin materials and a more comprehensive deposit-refund system for consumer products, or by developing new business models. I will suggest such a system in this thesis, and discuss some of its effects, advantages and drawbacks.

The conservation of virgin material and eco-systems is crucial, because they have an intrinsic value for society and future generations. Perman (2001) argues that maybe its not important to focus on the amount of resources we leave for future generations, but rather that the system we hand over is highly functional, and provide the essential means for humans to thrive. The latter part certainly is a good argument for circular production, as the resources are used much more efficiently through recycling. However, I think this is a futile mind-set, as future generations might develop much better ways to utilize the resources than we do today, e.g. the burning of products that are made of carbon. We should therefore preserve a certain amount of as many virgin resources as possible, so that they can be studied and utilized for increasingly beneficial purposes by future generations. In the ideal future there will not be waste management, in fact, we should envision an economy were there will not be any waste at all, because every material is reused to make new products or new materials, or sustainably returned to the environment.

Bonilla et al. (2010) provides a fitting argument to end this introduction, and serves as a justification for this thesis:

"Sustainable development, due to its philosophical and multi-disciplinary and long-term horizons, requires a new set of visions, paradigms, policies, methodological tools and applicable procedures to be developed, tested and widely applied, IF WE ARE TO MAKE THE URGENTLY NEEDED CHANGES FROM UNSUSTAINABLE TO SUSTAINABLE SOCIETAL PATTERNS." (Bonilla et al. 2010)

Thesis, research question and goal

My thesis statement is:

- Current EPR recycling initiatives and related policies are not enough to enable the development of a circular production system

My research question is:

- What are suitable policy tools that can support an effective strategy for a transition into a circular production economy?

The goal of this master thesis is to:

- Provide suitable policy tools for a strategy that enables a transition into a circular production for a given industry that uses virgin materials as input. This strategy can serve as a model for governments that wish to become part of the circular economy

The implementation of the strategy must lead to a desired end state. The desired end state is that the producer changes the sourcing to renewable materials, in order to enable circular production, as opposed to linear production (see figure 2).

That implies that there should be some measures that must be clearly improved if the strategy has been used. More measures increases the complexity of the analysis, so in order to keep the analysis rigid and consistent, I will focus on three measures that I intend to improve:

1. A decline in the extraction and use of virgin raw materials
2. An increase in consumer and producer participation and responsibility
3. A decline in the amount of waste generated

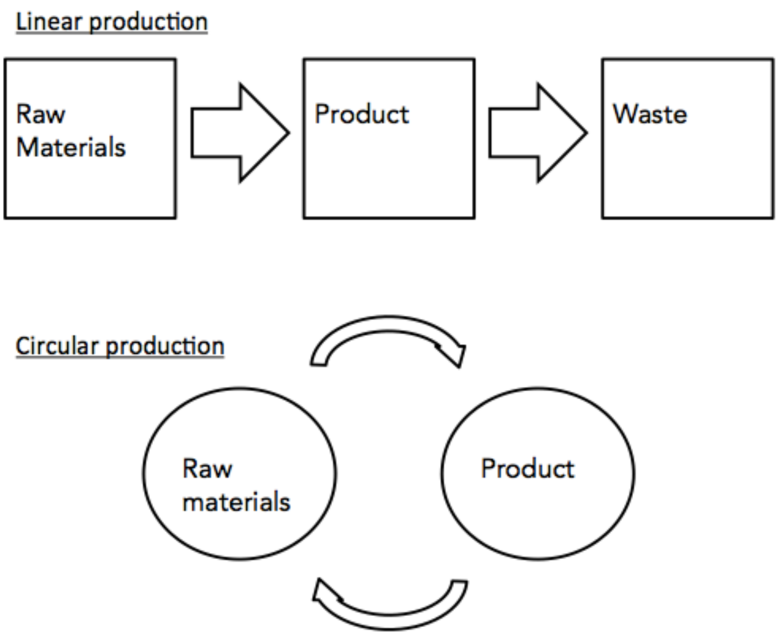


Figure 2: Linear and circular production

Methodology

I will use desk study to find answers in this thesis. I will not use structured interviews or quantitative analysis in this thesis, which means I will not get quantitatively reliable data from the research. This can be seen as a disadvantage, but in every research project, one is forced to apply certain limitations. In this aspect I will rely on the research that has already been done by other researchers.

I have tried to find sources that are written recently, as this industry is developing fast. However, some earlier studies can have been highly influential and must be assessed in order to get the full picture. One way to find these studies is to assess how many researchers that have cited the articles, like you can see on Google Scholar, or by assessing the articles. After reading many articles, you get an impression of which authors that are reoccurring. On the other side, it is important to include other authors that are not part of the "mainstream" in order to get a broad understanding of the featured concepts. Other older sources can also offer important insight that has not received as much attention as it deserves, and I have tried to find these sources as well. It is also relevant to consider the different parts of the articles separately, as some sections can be of higher academic quality and relevance than others.

There is a vast amount of research on this subject. The search for circular economy in the "Oria" database for Norwegian libraries alone resulted in 2223 hits. I have therefore concentrated on using sources that are considered to be credible in that they come from globally recognized research institutions, and have been reviewed by peers. For the reports, I have used highly credible sources, such as the UN, OECD and ISWA. I have also focused on using articles from authors from different parts of the world, as production and waste management is a global issue due to globalization, and in order to get different perspectives on the concepts and policies from around the world.

Another important aspect is to assess the methodology used in the sources, in order to decide on what weight one should give to the conclusions presented in the article. This can be challenging in this subject, because many of the topics are conceptual, and many of the policies have not been in effect for a long period of time.

Literature review and theoretical discussion

In the following review I will discuss research literature for the topics I find most relevant within the Circular Economy framework in order to analyse the thesis statement and answer the research question. First, I will look at the Circular Economy concept and then how connected aspects can contribute to its fulfilment, such as Extended Producer Responsibility (EPR) and its effects, Product Stewardship (PS), the use of taxes to sway producers, waste management and eco-design. These topics are to various extents interrelated with other topics, which make it difficult to separate them from each other, and they will therefore be discussed somewhat randomly.

Circular Economy (CE)

The concept of circular economy has been discussed and developed in a wide variation of academic schools of thought (Ghisellini et al. 2016), but the concept has gained traction in recent years, leading to the establishment of different advocating organisations, with possibly the Ellen MacArthur Foundation as the most prominent.

Tim Jackson (2012) is a university professor who claims that our current linear economy stays stable only if it is growing, and this is disastrous for the environment. He emphasizes two economic principles are important: Investment and enterprise. In CE investment has to mean protection for our assets so we can use them in the future, especially ecological assets. Therefore we need slow-moving capital. These investments have to be integrated in new enterprises. We need a service economy and not an ownership economy. Traditional economy chases labour out of the enterprises in the pursuit of labour productivity. When you chase labour out of health care, education and renovation, these services are degraded. The continued shareholder capitalism drains money into a minority of the population and damages the circular economy. The ultimate aim of the economy is to provide us with prosperity and we do not need continued growth to maintain prosperity in a circular economy.

Jasmin (2014) states that if circular proper production is implemented, material input cost savings can amount to 630 billion US$ annually for medium-lived complex goods (mobile phones, cars, machinery, home appliances, furniture etc.) in the EU and 700 billion US$ for fast-moving consumer goods (food, packaging, clothes, hygiene articles etc.). There are also energy savings to be made, companies become more resilient to shocks and fluctuating prices on raw materials, and they can find new sources for revenue by developing new business models. It also means that the customers can get high-quality products at a lower price.

There are remarkably few articles that critically analyse the concept of circular economy, something that is also found by Gregson et al. (2015) who provides one of the few critical articles. This might be due to the fact that it is a fairly new concept, even though the ideas have existed for many years. Another reason might be that many researchers support the concept, and want to see it being implemented, leading to less scrutiny. This should be avoided, in order to properly develop the concept into a functioning economic principle. Gregson et al. contributes to this, and states that there are considerable challenges involved in turning waste into resources in the EU, and that EU Circular Economies are "moral economies" because they only allow certain high-quality forms of recycling (Gregson et al. 2015). Others criticize the EU policies for being too weak (de Man & Friege 2016).

Upstream combination tax/subsidy is a policy where producers pay a tax that is used to subsidise waste treatment (OECD 2001). Palmer and Walls (1999) claim that the UCTS makes the manufacturers pay some of the costs of ultimate product disposal, but that it also discourages production, which reduces waste:

"To be efficient and cost-effective, a policy must have both an output effect and an input substitution effect--i.e. discourage production or encourage greater material efficiency and encourage cost-effective substitution of "cleaner" inputs to production for "dirtier" ones. In the case of life-cycle concerns, this input substitution effect includes substitution of pollution abatement efforts for other inputs and substitution of recycled for virgin materials" (Palmer & Walls 1999).

Sheu and Chen (2014) argue that governments should act as mediators that facilitate the integration of supply and reverse-supply chain members. They also state that:

"…the appropriate use of economic instruments can have positive effects on facilitating recycling systems and improving products with an eco-friendly design." (Sheu & Chen 2014)

Jasmin (2014) argues that in a circular economy, it will be imperative to completely separate biological materials from what she calls "technical materials" such as plastics, metals, glass etc. (Jasmin 2014).

EPR and results from EPR policy implementation

The OECD defines extended Producer Responsibility (EPR) as follows:

"EPR is a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products" (OECD 2016).

This is a broad definition of the concept, but it is widely recognized as policies that to various extents apply more pressure on producers to take more responsibility for their production, in order to develop a more environmentally sustainable production. It is important to note that:

”EPR is not limited to financial obligations for producers, but also included information, logistics, waste management and even product design responsibilities” (INSEAD 2014).

Nahman (2010) provides the following definition:

Extended producer responsibility (EPR) is a policy concept aimed at extending producers' responsibility for their products to the post-consumer stage of their products' lifecycle. (Nahman 2010)

Germany initiated legislation against packaging waste in 1992 which were copied by several EU member states and the EU established the Packaging Waste Directive in 1994, the EPR for End-of-Life Vehicles in 2000 and the Waste Electrical and Electronic Equipment (WEEE) in 2003 (INSEAD 2014).

Nahman (2010) found that mandatory, government-imposed sanctions did not produce incentives for the recycling of plastic bags, but it did indirectly lead to more recycling of glass and PET bottles, because these companies tried to avoid mandatory sanctions by increasing voluntary recycling. It is also more difficult to recycle plastic bags, especially the soiled ones that have been in bins. (Johnson & McCarthy 2014)

The WEEE Directive had a substantial positive environmental impact, by diverting electronic waste from landfills, reducing CO2 emissions by 36 million tonnes per year and the creation of Producer Responsibility Organizations (PROs), which manages the retrieval of products and materials for the producers. But this came at a cost; the technical costs for the recycling may reach 3 billion euros before year 2020 (INSEAD 2014).

Furthermore, the collective nature of WEEE has been widely criticized. The INSEAD report states:

”Collective implementation creates minimal incentives for producers to design their own products for repair, reuse or recycling” (INSEAD 2014).

This is an important aspect to consider, because it can lead to solidification of current production practices, instead of changing it towards sustainable production. The WEEE Directive also failed to create holistic recycling standards:

”For instance, when recycling essentially comprises simple shredding and metal separation, precious and valuable metals find their way to commodity markets and residual materials that contain potentially hazardous substances continue to end up in landfills or incinerators. (INSEAD 2014)

The lack of coherent implementation in and between the EU member states also lead to poorer results:

"Moreover, differing transpositions of the WEEE Directive led to varied and sometimes contradictory national legislation across Member States, increasing the complexity and administrative burden for producers. The lack of enforcement of national legislation by some Member States was another shortcoming limiting the environmental benefits expected from the WEEE Directive" (INSEAD 2014).

This is also stressed by Kevin Scoble from the Wood Buffalo Municipality in Alberta, Canada, who emphasizes the importance of a collaborative approach to establish a comprehensive waste treatment system. Their system combines the effort of different stakeholders to extract as much value as possible from the waste stream (Scoble 2012).

Producers are the main stakeholders in EPR as they bear the responsibility for financing or operating EPR implementation at the national level. Their preferences rely heavily on having a simple, stable and cost-efficient implementation which ensures that all actors are playing on a level field. (INSEAD 2014) They further acknowledge that light weight products can last shorter, extending the life span can lead to slower technological development, and material recovery and recycling may have undesirable side effects because of transportation costs, energy use and emissions (INSEAD 2014).

Other authors writes that WEEE has resulted in high recycling rates, reduced emissions of GHG and other toxins, greener production and reuse of products (Nicol & Thompson 2007). Conversely, they state that cost-effective recycling solutions is not always connected to environmental benefit, because of the missing link between recycling and actual costs. They also emphasize the importance of sharing of responsibility between the stakeholders.

In addition to this, Favot and Marini (2013) found that the WEEE directive increased product prices with an average of 2,19%, with good validity due to high significance from the t-test. This means that some of the burden from the tax is levied on the customers (Favot & Marini 2013).

Niza et al. (2014) writes that EPR systems in Portugal have become crucial elements in the prevention of environmental damage from poor waste management. EPR policies have lead to increased waste recovery and recycling and just competition between waste management operators. But, there are still challenges related to increased landfill taxes and no more waste provisions. However, the PROs have established themselves as important stakeholders, together with a specialized group of recyclers and disassemblers. Portugal imports a lot of their products, or makes products that are designed in other countries, but the PROs can find new use for discarded products (Niza et al. 2014).

However, Milanez & Bührs (2009) argues that it might not always work to export policies to other countries as they assessed the case of tyre waste in Brazil. They emphasize that countries have very different prospects of managing successful EPR initiatives, due to the big differences in resources, competence and infrastructure.

EPR, pricing disposals, landfill taxes and prohibitions have increased demand and the amount of recovered materials, particularly in developing countries (GWMO 2015).

Hage (2007) investigated packaging fees in Sweden and compared the Swedish producer responsibility regulation with a hypothetical upstream combination tax/subsidy (UCTS) system, to see if the UCTS system could be more cost-effective. The UCTS system combines a tax on produced goods with a subsidy to collectors of recyclable material. He found that both systems cause a substitution effect between materials and that they encourage recycling, because the price on recycled material goes down. However, he also found that only the UCTS system would promote cost effective collection of waste, and most importantly, neither of the systems strongly encourage design for recyclability. Hage points out that when you implement a policy to reduce weight, the producer might choose materials that are more difficult to recycle. The fact that the author uses a hypothetical system for comparison makes the study less reliable (Hage 2007).

Da Cruz et al. (2014) found that externalities were not covered by producers, even though a packaging waste management fee was introduced:

> " …the industry is not paying for the full costs of packaging waste management in any of the countries (i.e. the transfers plus other financial benefits are not enough to cover the costs of local authorities)" (Da Cruz et al. 2014).

Others argue that a mix of the use of Producer Responsibility Organizations (PROs) and market power in the downstream waste market may asymmetrically hurt producers that intend to initiate EPR. They also claim that individual EPR initiatives by each producer always lead to higher welfare than perfectly collusive PROs. In addition; the downstream waste treatment firms distort the product market more than perfect collusion does (Fleckinger & Glachant 2010).

This is supported by Massarutto (2014) who states further that upstream innovations have been used as marketing strategies rather than being driven by EPR.

Massarutto also reminds us that EPR has caused the creation of a new and highly successful recycling market, and has made cost sharing widely accepted in the market. Market distortions are inevitable in the beginning, but increased competition is now making the market structure more effective. But, and very importantly, there are still huge waste streams that need to be tackled, and it is necessary to obtain control over these streams (Massarutto 2014). Recycling now has an annual turnover of over 200 million USD (GWMO 2015).

Lyons (2009) also found that the recycling firms could be promoted as a way to close the loop at the local level for some items. I note that some of the questions in his questionnaires are biased, which make the results somewhat unreliable (Lyons 2005).

Kojima et al. (2009) highlights the difficulty of identifying every producer within the recycling industry, because they are small-scale, numerous and widespread, and because some of them can be involved in smuggling and overreporting of collected e-waste, the government should increase efforts to prevent this, such as monitoring systems and tightened border control. Another question is the feasibility of placing the burden of proper disposal on these small-scale producers (Kojima et al. 2009).

Lifset et al. (2013) remarks that "the data and accounting challenges in calculating and allocating costs and benefits in EPR programs are truly daunting." They call for much more data and consistent and transparent accounting systems to improve the performance measurements of EPR policies in different countries (Lifset et al. 2013).

Product Stewardship (PS)

Responsibility in product stewardship (PS) is defined by Thorpe et al. (2004) in Nicol and Thompson (2007):

> "Ideally, responsibility is divided up as follows: producers ensure that collection and recycling infrastructure is in place, consumers pay levies and deliver the product to collection points, retailers participate in collection of waste, and governments establish standards and ensure free riders do not take advantage of the system" (Thorpe et al. 2004).

Other authors found in their study that EPR initiatives gets far better results than PS, because EPR programmes with precise targets reduces waste and motivates DfE changes in consumer purchases, but PS externalizes costs, does not provide incentives to reduce waste when products are designed, and lacks regulation that increases recycling or reduce emissions (Nicol and Thompson 2007).

Other authors has pointed out that product charge policies are not always effective, for example with the case of a product-packaging fee in Denmark. They advice governments to proceed with caution when implementing these policies on products that have a price-inelastic demand (Cela & Kaneko 2013) (Blomberg & Söderholm 2009).

Wagner (2013) writes that responsibility within EPR and PS is usually allocated to specific waste such as batteries, lamps or beverage containers. He states further that both frameworks are dependent on consumer participation:

"Consumers, who generate the waste, must sort and segregate the material, store it, and then transfer it to the kerbside or more likely transport it to an offsite collection site to place it in specifically designated areas or containers" (Wagner 2013).

Lenzen argues that the responsibility should be shared between the producer and consumer (Lenzen et al. 2007). I agree strongly with this, because the producer and consumer are mutually dependent, and should share both the costs and the benefits of market transactions.

Taxation of virgin materials

Sniegocki et al. (2016) suggest a material tax for all materials that are used in the EU, and that it should be put on renewable materials as well, in order to increase efficiency on all materials. They further state that recycled material is insensitive to changes in demand and an exemption from the tax will therefore not increase total recycling. The tax should also be imposed on imported materials, and this makes it difficult to apply to only virgin materials, because they are often mixed with recycled materials. They concur that the tax needs to be high to affect the material efficiency, because of the inelastic demand for materials, but that it should be introduced at a very low level in 2020, and then increased to 30% of the net value of the material and 200% of the net value in 2050. (Sniegocki 2016)

Bruvoll (1998) stated that taxation of virgin materials leads to improved market efficiency, because relative prices (in 1998) between virgin materials and other input factors will promote inefficient resource allocation. Taxation is also in general more effective than regulation, but biased tax policies and regulations are particularly harmful because they lead indirectly to subsidization of virgin materials. She found further that a tax of 15% on plastic and paper would result in an 11% decrease in the use of these virgin materials. This would, however, cause a decline in production and consumption, which is softened by an increase in productivity as a result of improved environmental production (Bruvoll 1998). This is a fundamental focus area in order to achieve circular production, because the tax aims to reduce the extraction of raw materials.

Bruvoll et al. (2011) emphasizes in a later study the need to remove environmentally harmful and costly subsidies, in order to promote the development of a more sustainable production economy, and cite a study by Ellis (2010) which found that subsidies could account for as much as 15% of GDP in some developing countries. They argue further that diversified income taxation is an important tool to prioritize low income groups worldwide (Bruvoll et al. 2011).

Dubois (2012) proposes an additional tax on non-collected waste through existing PROs. This would internalize the cost of waste disposal and create more efficient price signals to stakeholders. EPR is criticised because of their static collection targets that leads to market inefficiency and low incentives for waste prevention and green design. She also states that the literature has plenty of examples which shows that taxes are far more efficient than targets (Dubois 2012).

Søderholm (2011) states that aggregate taxes has significantly affected material substitution, and that countries with higher recycling rates tend to have high tax rates, but that tax is just one of the policies that affect the recycling rates, an that it is important to analyse how these policies interact with the aggregate market.

Sinn (2009) introduced the green paradox, which has led to a lot of discussion. The green paradox states that increased subsidization of e.g. sustainable technologies will cause ramping up of production from e.g. raw material extractors due to environmental policies that subsidize green energy increasingly, inducing the premonition of future declining profitability for the raw material extractors.

However, Van der Ploeg and Withagen (2012) draw two main conclusions from their study on the green paradox. They find that if renewable energy is being used in a larger scale first, and then subsidized so that the price goes down, the oil production will either be postponed or more oil will stay unextracted. Conversely, if environmental externalities are not internalized with the oil producers, and renewable energy is still at a low supply level, there will be full depletion of the oil resources after a certain time, and a renewable energy subsidy will increase the rate of oil extraction (strong green paradox). They also find a weak green paradox that arises from decreasing subsidies. (van Der Ploeg & Withagen 2012)

On another note: Cairns (2014) argues that:

"Exhaustibility in itself does not entail a special form of market failure. In particular, competitive markets are not subject to a myopic inability to allocate an exhaustible resource in a way that efficiently balances the interests of the present and the future" (Cairns 2014).

Waste management

Lyons defines waste as:

"something that is perceived to have either no inherent value to its owner, or the amount of effort required to access that value is greater than the expected return" (Lyons 2005).

Some authors highlight the importance of establishing policies directed towards resource management, instead of waste management (El-Haggar 2007). The important focus of the policies should be to decrease the absolute consumption and resource depletion in stead of increasing the relative efficiency in the use of materials (Lilja 2009).

Wagner (2013) emphasizes the importance of developing convenient waste collection systems to increase consumer participation and the fact that many people have insufficient storage space for waste in their homes.
He states that a separate and parallel collection and management system is necessary. He also remarks that: "The amount of storage required also is a function of the number of different wastes being accumulated and segregated" (Wagner 2013). Others advocate flexible systems that can be adapted to different needs (Di Corato & Montinari 2014).

Moreno-Sanchez and Maldonado (2006) addresses the waste-pickers situation in their study and develops a dynamic model. The authors proposes three actions based on their model: consumers should pay a per-unit tax on consumption, waste-pickers should receive a per-unit subsidy for collected material and producers that use natural resources as inputs should be charged a per-unit extraction tax. The authors emphasize that the latter is not a tax that aims for a reduction in waste, but targets the externality from raw material extraction. (MORENO-SÁNCHEZ et al. 2006)

Zaman (2014) has studied the zero waste strategy in Adelaide, Australia, and states that even if a city achieves a 100% diversion rate from landfill, this is insufficient to fulfil the goal of the zero waste ideology. Even though Adelaide has a very high composting share, it must develop the biological waste treatment infrastructure further. Also, it does not put enough effort into optimal resource recovery from waste. (Zaman 2014)

Sanjeevi and Shahabudeen (2015) suggest five key performance indicators (KPIs) to measure municipal solid waste management (MSWM) in a simplified manner:

1. Collection cost (CC) - cost incurred for collection from generating points, that is, mainly households, parks as cost per metric ton

2. Transportation cost (TC) – cost incurred for transporting SW from generating nodes to sink nodes, cost per metric ton (to dumping yards, recycling point)
3. Social perception (SPC) – percentage of citizens not satisfied with SW collection service (need to ascertain through a quarterly survey with simple questionnaire, designed according to local needs and may be a statistically significant sample to be obtained).
4. Social participation (SPP) – calculate the percentage of homes that separate waste into recyclable, compostable and others. (This may be collected even on a daily basis by the garbage collectors and reported quarterly for policy changes in terms of incentives and penalties. Many cities such as London follow this, where the household/personnel who do not separate waste are compelled to dump the waste at their own cost in a faraway place.)
5. Environmental impact (EI) – percentage of waste that is recycled."

Table 1: KPIs for MSWM (Sanjeevi & Shahabudeen 2015)

Rashid (2008) and his colleagues have made four types of distinctive waste strategies: waste minimisation, material efficiency, resource efficiency and eco-efficiency, as shown in figure 3. They state that eco-efficiency has a broader scope, but is more difficult to assess and measure, than the other strategies.
(Abdul Rashid et al. 2008)

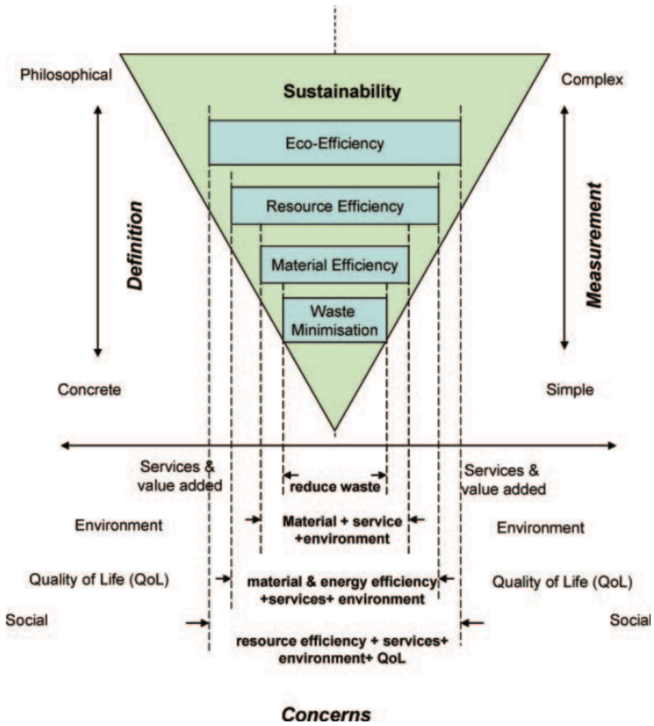


Figure 3: The hierarchy of sustainable strategy (Abdul Rashid et al. 2008)

Reh (2013) underlines the importance of strengthening process-engineering capabilities in order to reach the goals of the circular economy. He stresses the principle of entropy as a guiding and limiting factor in pursuing knowledge about global production and transaction, and how to maximize its efficiency. He advocates the rational use of resources in all process industries, and says that:

"High energy and material efficiency in production as well in recycling processes save valuable resources and are the way into a sustainable future."
(Reh 2013)

He states that the world needs more funding for research on recycling materials, but that the recycling of all products is impossible, and that maximizing resource efficiency, and selecting the most valuable components is the best action (Reh 2013). This is also supported by other scholars (Huesemann & Huesemann 2008) and Jasmin (2014), who argues that the development of the circular economy requires education and re-thinking of the production economy, policy and regulations, and collaboration between stakeholders across sectors, geographies and businesses.

Additionally, another group of researchers found that the use and separation of paper-waste after recycling might need to be reformed to extend the number of lifecycles of the material. They used a Markov chain model to evaluate the performance of the recycling process. (Chen et al. 2015) This is very important research, as we need to know the limits for the repeated cycles, and how to increase the number of cycles.

Hickle (2014) remarks that recycling, product innovation and development of product-service combinations will be increasingly important in supporting U.S. competitiveness in the global market (Hickle 2014).

Other researchers found that the number of firms that started to develop eco-design only increased marginally when a recycling fee was introduced. However, a combination of taxes and R&D subsidies leads to radical innovation, as in the case of TaxSub, where a majority of companies switched to eco-design (Brouillat & Oltra 2012).

Jasmin (2014) argues that from a CE perspective, you don't look at how well you can use the resources from the product after the consumer returns it; you start in the other end, by designing the product for recycling. It should be designed so that it is easy to disassemble, upgrade and lasts longer, design it for upgradability and improving the treatment of the materials to increase the value of the product. This makes remanufacturing profitable and increases the integrity of the value of the product. One of the key success factors is that the products are returned for remanufacturing. You can do this by using a deposit-refund system or by creating a new business model that rents out the product to the user. Consumers want access to products, but don't necessarily want to own them. The possibilities for remanufacturing and renting it out again means that the producer can "sell" the products several times.

This is also supported by Bocken (2016) who states that:

"...we need several business models, and design strategies, approaches, methods, and tools to support the move to a circular economy. " (Bocken 2016)

Plepys et al. (2015) takes the idea further and explains the concept of servicizing:

"Servicizing is a business model that holds the potential to support a shift towards more sustainable production and consumption by selling to the consumer the product's function, rather than the material product itself. This can offer direct environmental benefits by reducing the material and energy intensity of market transactions." (Plepys et al. 2015)

They also argue that servicizing has three significant advantages in that it reduce production costs through optimized resource use, satisfies fast changes in consumer needs and creates long-term customer relations (Plepys et al. 2015).

Kannegiesser et al. (2015) introduces a Time-to-Sustainability model with three different variants in order to assess the time needed to achieve sustainable supply chains (Kannegiesser et al. 2015). This seems like an important instrument to develop proper practices.

Summary of the findings from the literature review

In general, I find much of the literature to be highly biased. The bias indicates that some of the concepts are being portrayed as the golden solution, and unfortunately, less objective analysis. Even though it can be argued that the concepts has many inherent aspects that are logically plausible and sensible, the theory must none the less be put under the magnifying glass. This requires more scrutinizing research.

However, there are some conclusions to be made from the review, which will serve as the basis for my discussion. I will state the main conclusions:

1. EPR and PS policies has increased recycling and consumer awareness and made the producers more financially responsible for their externalities, but

they seldom reduce the externalities drastically, leading to a slightly improved status quo.

2. Taxation can be a powerful policy tool to change production practices and internalize externalities, but should be applied uniformly and with clearly stated targets, and used in collaboration with other essential policies, such as increased consumer participation systems.

3. The concept of waste management should be transformed into resource management, and must encompass a practical collection and treatment system.

4. All products should be designed with maximum resource-efficiency and research on recycling should be increased.

This confirms my thesis statement; however, certain policies and instruments have laid down important groundwork for the introduction of circular production policies. In the following discussion I will discuss possible answers to the research question.

Discussion – The transition to circular production

In the following paragraph, I will discuss the findings from the literature review and provide the justification for the suitable measures that provides the best transition into a circular production from my point of view.

This master thesis started out as an analysis of which recycling method that could create the highest economic value. It soon became clear to me that a lot of different techniques need to be combined in order to derive the highest value from the reuse of different materials. It also became evident that the main reason for our need for extensive and proper waste management is mainly due to our linear economy, which is fundamentally flawed in one important aspect. It does not give weight to the sustainability of our natural resources, and focuses mainly on their current value versus their future profitability. The main argument for this in regard to my thesis, is that it is economically contra-productive to create a waste management system that works for the current linear economy.

This drew me to the concept of developing a strategy for the transition into a global circular production system in order to create a circular economy that puts environmental sustainability in the drivers seat. The intention behind this transition strategy is to "slow down" production, hence slowing down the extraction of raw materials. The current production economy is to a large extent built around the principle of planned obsolescence, in which products have a predetermined, often short, lifecycle, so that eventually it is turned into useless waste for the consumer, thus giving her incentive to buy a new product.

If this product is fixed it removes the incentive for the consumer to buy a new product, and the producers loose a customer. Even though this is the best environmental alternative, it hurts the economy. Because it takes time for the businesses to transition into the new economy, there should be a planned phase for resetting of the market edifice in order to avoid long-lasting inefficiencies. I refer to this as the "transition phase". The production economy should be organized in such a way that it accommodates every customer's need. It is probable that customers will continue to have a highly diversified purchasing power in the foreseeable future, which gives the producers incentives to continue to provide a broad product range.

Miele is an example of a company that makes products which have a longer than average lifespan. Their washing machines will last for 20 years, according to their own advertisement (Miele 2016). Thus, their business model relies heavily upon their reputation for making high-quality machines that might cost more, but lasts longer. While their machines lasts longer, they are not circular as they cannot be completely disassembled into separate parts that all can be used again.

Instead of slowing down the economy by selling fewer products, the producers should source renewable materials and design the products for planned recollection and disassembly. This opens up for new profitable business models connected to leasing and renting out products. One could also put a deposit premium on the product that can be reclaimed by the customer when it is delivered to the recycling company.

Many of the new circular economy companies that are emerging are to a considerable extent basing their business model on the conscience of the customer. Even though many people are getting more environmentally aware, and want to buy eco-friendly products, they are still heavily influenced by other factors regarding their purchasing situation. Factor such as price, trends, fit, social stigma and perceived needs play an important role.

A good example is from the fashion industry, where many companies have tried to be green to attract customers, but style and price is often dominant over conscience when customers buy products. However, it is reasonable to believe that an increasing share of the customers are becoming more environmentally aware as a result of the focus on global warming and our impact on the eco-system in the media. Fairphone is a company that produces "socially responsible" cell phones and they sold 60 000 units of its first generation cell phone in two years (Fairphone 2013). In comparison, the first generation iPhone was sold to 1 000 000 customers in 74 days (Apple 2007). Even though it is not a justifiable comparison, due to the high anticipation of the iPhone and other factors, it gives some insight into the powerful drivers behind the customers' preferences and willingness to buy "responsibly".

The important lesson is that it cannot be up to the consumer to decide if circular companies should succeed or not. The consumer is mainly concerned with covering her own need first, and what is most important for her in the moment of purchase. However, the consumer should take more responsibility for their consummation of products, and contribute more to the reuse of materials. The entire production industry must be guided into this new production practice by governments, companies and organizations, making a multi-stakeholder approach imperative for a successful transition.

Some claim that if all waste had a certain value, you would not see any waste lying around, because someone would profit from it. I would like to refine this statement by saying that if every piece of waste had an intrinsic opportunity for profit e.g. a specific place it could get delivered and in return you got money, all waste would be defined as used resources. Recycling is becoming increasingly more attractive, and will soon create profit without fees being paid by consumers or companies (GWMO 2015).

One could argue that increased prohibition of certain materials by governments is the only way to force producers to change their sourcing into renewable materials. But such a rash strategy could have serious consequences for many companies, and might force them into closure. It could also lead to shortages, which hurts the consumers and the economy, yet this is more important for certain goods. A controlled phase-out of unsustainable production system is a better solution, as it gives the companies and consumers time to adapt to the new system. This must be done firmly and steadily over a certain time period, but, the faster, the better, as our environment would greatly benefit from a swift transition.

An important aspect of this transition is to phase out materials that are harmful to the environment and difficult or costly to recycle. Plastics such as PVC, PS and ABS should be phased out and replaced with alternatives that are easy to recycle, without the emissions of chlorine gas, dioxins and other harmful chemicals. A great deal of research is needed to find methods and materials that can be used to create renewable products. This can also lead to the development of new profitable industries.

If we truly want a circular economy, every product must be a cycle in itself.

To make the production more circular, the use of arable organic materials must be heavily increased in production. This also requires extensive research and innovation. Ideally, the raw materials should be sourced from organic material that is easy to grow and environmentally sustainable to grow in a large scale. One problem is that organic packaging has a shorter shelf life because they expire quicker. Research can lead to important improvements in this respect and others. Another problem is that we simply do not know how to disassemble and reuse many materials. Delaminating and dealloying is another area that requires research (Nature 2016).

The principle of circular economy also needs to be streamlined and aligned to only mean one thing. If it is defined to broadly, it means nothing in the end.
If the circular economy is rationalized, it is easier to create complete value chains for companies. As Walter Stahel (Nature 2016) said, we should use fewer raw materials and create more jobs.

The principle of planned obsolescence could be optimized to fit into the new sustainable economy. This gives a high degree of structure and oversight for the producers, and reduces the risk. For example, every car has a five-year lifespan. In this time the car is covered by a guarantee, making sure that the customer has no problems. When the car is obsolete, it is returned to the manufacturer and every part of it is redesigned or recycled. This both secures a constant renewal of the global car park to make sure people are always driving the most secure and environmentally friendly cars, and it keeps the car manufacturers going. Toyota are frontrunners in this development, as they have developed a comprehensive recycling strategy (Toyota 2014). The problem is that a lot of companies don't think about what happens to their products at end of life (Nature 2016).

Another example is the huge structures we build today, such as skyscrapers. Some of them need to be removed from time to time, and they are often demolished. This is considered to be a much cheaper alternative than dismantling them manually. But if you consider all the different materials in a skyscraper, such as glass, concrete and steel, there is a lot of material value that can be exploited through the reuse of these materials. The problem again is that the structures are not designed for disassembly. Some people argue that these mega-structures should be designed to never come down, but that is a risky strategy. The pyramids have lasted for around 4500 years, but that is on behalf of their unique shape and materials. A tall structure consisting of several materials runs a higher risk of receiving damage, for example from earthquakes or other natural disasters. They can be very difficult to repair, and it might not be safe to keep them standing, if the integrity of the structure has been compromised. That leaves no option but to dismantle or demolish the building, and demolishment might lead to significant costs and extensive after-work connected to the enormous amount of debris. Last year, the US threw away some 75% of their construction and demolition debris (Nature 2016).

If we could analyse this system using Sajeevi and Shahabudeens (2015) key performance indicators (KPIs), I would argue for the following:

CC
These would drop for governments and increase for the consumers in terms of time, because consumers return their materials for recycling.

TC
This could be reduced, because of decentralized recycling points coupled with decentralized production, but a thorough transport chain analysis needs to be done to assess the effects.

SPC
Many people will be dissatisfied with having to return their materials themselves, instead of having them picked up. A certain degree of collection will still have to be maintained for those who are not able to deliver the materials on their own. However, an increasing number of people are becoming environmentally aware, and will appreciate their own contribution to sustainable production.

SPP
This will increase dramatically, because significant value is bound up in the materials that the customers deliver. This will strongly encourage consumers to deliver their materials. The ones that don't, will be subject to expensive and more-time consuming alternatives, such as in London (Sanjeevi & Shahabudeen 2015), which eventually will be prohibited.

EI
The environmental impact of such a system will be profound, because it changes the production and resource management into a sustainable and controllable system.

The entire process could be like this:

1. Used material is produced in various sectors
2. Everybody puts the material in containers and it is then transported to facilities where it is segregated or people segregate by themselves and then puts it in containers. (Employment vs. efficiency)
3. The material is sent to its proper processing facility, for recycling, composting or remanufacturing

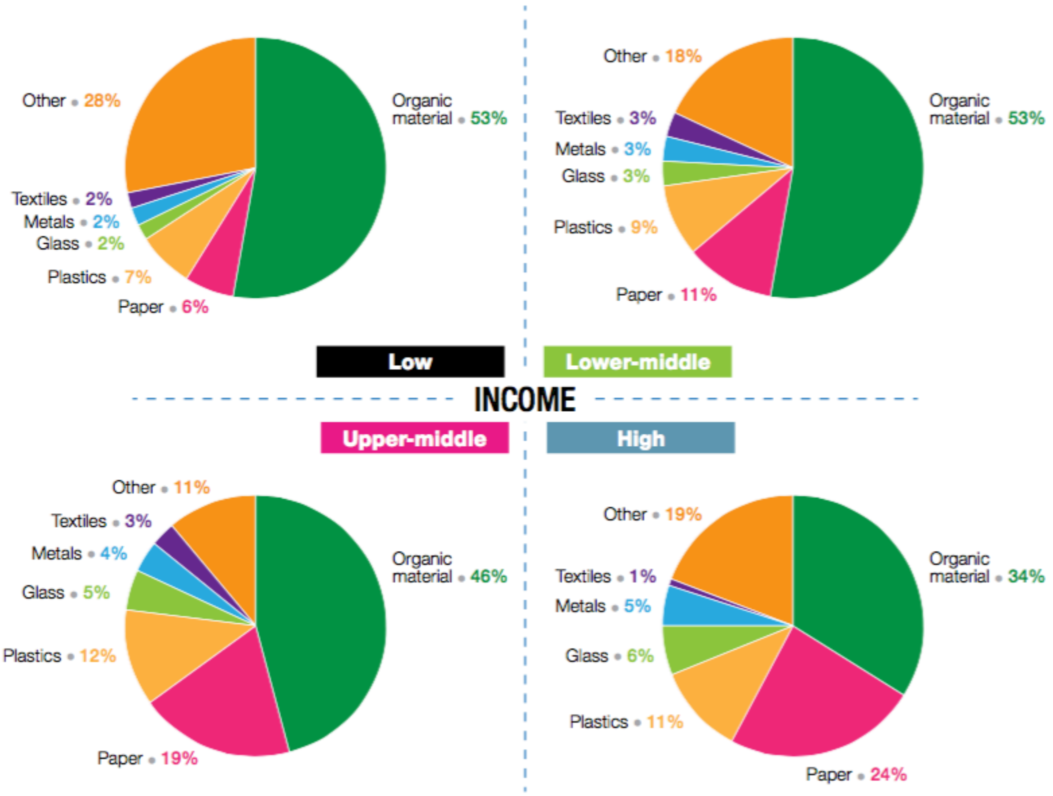
4. The material is then sold to other companies that use them to produce new products
5. Important improvements: as much as possible should be bio-degradable, non-recyclable materials should be forbidden, the rule of law, the requirements of producers should be very strict: they must prove that their production is clean, cyclical and sustainable

Strengths - circular businesses - consumers - scientists	Weaknesses - Advanced recycling technology requires the use of machines and robots which removes labour -
Opportunities - government subsidies to circular companies - government tax on non-renewable practice - new jobs - environmental effects	Threats - invested capital and infrastructure, owners - employees, workplaces - profitable linear businesses

Table 2: SWOT analysis for the described process

Waste management in the transition phase

In order to ensure a responsible transition into a new circular production system, we must ask, among other questions that will not be covered in this thesis, what waste management system is most suited to stimulate an early transition into a circular production economy, and at the same time obtain control over the increasing waste streams?



Notes: Based on data from 97 countries (22 in Africa; 14 Asia-Pacific; 35 Europe; 19 Latin America/Caribbean; 2 North America; 5 West Asia). Dates of the data vary between 1990-2009. "Other" means other inorganic waste.

Source: EMC's Master Country Database (n.p., 2014) using primarily data from the UN and World Bank and Hoornweg & Bhada-Tata (2012)[17]

Figure 4: Variation in MSW composition grouped by country income levels, Global Waste Management Outlook, UNEP/ISWA, 2015

As we can see from figure 4, the amount of organic material decreases as the income of the country increases. Paper, one the other hand, increases. The same goes for plastics, glass and metal (GWMO 2015). Since the composition of waste is unalike for different countries, it is important to establish waste treatment systems and policies in each country that are able to handle the distinct waste streams.

There is no doubt that technological waste treatment solutions such as biogas, composting, pyrolysis, waste incineration facilities and conversion facilities can be a good way to solve the waste problem. Yet, even though they can get rid of the waste, and even create a lot of value from it, it represents a direct threat to the vision of having a circular economy. The establishment of these facilities requires big investments, and the investors want to make sure that they get their money back and earn a nice profit. This requires a certain payback time. When the facility is up and running, it will have hired local staff, depending on the size, this could be a considerable number of people. The facility is then embedded in the society, and a lot of people would like to keep it there, especially if it's profitable. Before setting up these facilities, a lot of companies make sure to get long-term contracts with the governments, as a way to secure their investments.

More and more government agencies are now realizing the importance of implementing proper waste regulation. Waste management is on the agenda in the EU, UN and several environmental organisations. Governments in developing countries have an important task in creating the regulation they need to gain control over their growing waste streams.

We need to get control over the situation we find ourselves in right now. Developing countries are struggling to manage their waste, and in fact, they are to a large extent failing. They lack the capacity, knowledge and the resources to create and maintain proper waste management systems. It is therefore imperative that developed nations provide extensive assistance in setting up such systems to prevent the further expansion of landfills, and that garbage ends up in rivers and oceans. The goal should be to remove all landfills, and apply suiting technology in different areas. But, it is important to ascertain that the preliminary solutions do not become permanent. Incineration of waste can remove waste and provide electricity and heat, but we are at the same time burning valuable resources that can be utilized to extract higher value. We must remember that our natural resources are finite, and plan our production economy and waste treatment accordingly.

One of the main concerns is that by creating waste management industries you accentuate the linear economy, instead of putting efforts into creating circular production. The creation of waste management industries can form barriers against cyclical production, because when you create circular production, you remove the raw materials for the waste management companies. It is therefore crucial that the waste management companies are created with a strategy that specifically accommodates the shaping of new alternatives and that the owners and employees are aware of that their methods are merely temporary.

Whenever a profitable waste business is established, you create barriers for change.
It is also often difficult and costly for a company to change its business model. A company that has a successful business model will be hesitant to change it (Nature 2016). If pure value creation is prioritized, we create incentives to maintain the waste stream. We must therefore prioritize recycling into new materials as the main goal. It must be expensive to create waste, but cheap to create renewable materials. The circular approach can serve as a powerful driver for waste management and recovery.

It is very important that we make sure that our short-term solutions does not become future barriers to accomplishing change into a circular economy. If we have constructed industries with large facilities and hundreds of employees, it may be very difficult to convince these people that they should shut down their operation, and start doing something else, because we have come up with a better alternative.

In developing countries, this is especially important, because you might take away the job from someone who are in desperate need of employment. The new ventures must therefore make sure to employ the people that loose their job. An example of this is the dump in Payatas where the company employed the "scavengers" that were searching the dump for valuable materials. If a better waste management system is established, these people should be employed at the new venture.

The waste-pickers definitely deserve a higher income for their efforts, and they should be remunerated. However, the employment of waste-pickers leads to increased incentives for the continued use of landfills and will attract more people into the waste-picking businesses, causing more health problems and the flourishing of an unhealthy and unsustainable industry. The waste-pickers should eventually instead be employed in sustainable recycling businesses that contribute to the circular production.

The central aspect of the new waste management system is what kind of companies the governments attracts to take care of their waste. Some companies can create a lot of value and jobs, but they should also contribute to the development of circular production. In our eagerness to solve the waste problem, we must not fall in the trap of creating a waste management system that allows the producers to continue with business as usual. In this way, we help them to continue to deplete our virgin materials, instead of making them responsible. This emphasises the importance of long-term planning and governance, and proper regulation.

I support the notion that we are looking at the waste problem from the wrong angle, or rather; we are starting at the wrong end. Instead of focusing on how we can manage and treat our waste, we should focus on how our used products never turn into waste at all. Instead of speaking of a products lifecycle, implying that a product has an expiry date in which it becomes waste, we should redefine it into a product cycle, meaning that the product never becomes waste.

In order to achieve this, one must make the producers and consumers much more responsible for the products design and delivery, respectively. We have to develop a production system that recycles the products efficiently, instead of creating waste. This system should mimic nature in its efforts to create a fluent production and material recovery stream, that means that every product should have a recycle plan and path. I call it the Circular Enabling Resource Management System (CERMS). But, because it takes time to establish a new production system, we need to implement effective and easily disassembled waste management systems in the meantime.

A last note regarding waste: The use of the word waste implicates that the materials are to be disposed, changing this concept to "used resources" gives stronger associations towards reuse and recycling of materials. For instance, the concept of waste policy should therefore be changed to used resource policy in order to achieve better political justification for policy instruments.

Preferred policies in Environmental Economics

Environmental economics separates between first-best solutions and second-best solutions (Perman 2011). First-best solutions are the solutions that gives the highest amount of environmental gain for the smallest amount of money. In other words, first-best solutions are the most cost-effective solutions. This is useful when it comes to assessing e.g. which policy is the most cost-effective when it comes to reducing emissions, because this policy will lead to the highest reduction in emissions for a given government budget. But when it comes to assessing the long term-effects of industrial production, we need another set of tools that are better suited to assess the environmental consequences for our economic and social system.

I also find the dichotomy between first-best and second-best policies somewhat misleading, as second-best policies can be better in many aspects, such as social, political and long-term effects. It is used as an economic assessment tool, but the dichotomy gives the reader the impression that it includes more than just economic aspects. Describing the first-best policy as the most cost-effective would be more appropriate.

When it comes to the transition to a circular economy, the transition itself might require that we are not always pursuing the most cost-effective solutions, e.g. the establishment of new recycling businesses that cause increased temporary emissions before they optimize operation standards. In other words, we might have to sacrifice short-term cost-efficiency in order to achieve long-term cost-efficiency.
It should be a priority to not let long-term environmental goals get hindered by current environmental economics theorists focus on cost-efficiency. However, it is very important to control that the policies don't lead to unnecessary costs or environmental effects that will be costly to correct. In this respect the cost-efficiency assessment can serve as a key performance indicator.

Every product should have a defined lifecycle, but every material should have a cycle, instead of a lifecycle. The word lifecycle indicates that the product has a beginning and an end, which is reasonable as use, wear and tear will reduce the function of the product. It will also be appropriate to make new and more efficient products of the materials from the old products as technology becomes more efficient, as we do today with e.g. cars. Materials on the other hand, and to this respect, should have a defined cycle or maximum number of cycles instead of a lifecycle, to make sure that the material is used as many times as possible. To achieve this, the product must be part of a cycle that disassembles the products at the end of their lifecycle and the materials must be recycled in the most efficient way. This requires extensive research in material recovery and the related use of energy. It should also be a stated goal to avoid use of materials that are harmful to the environment or society in form of creating emissions and spills into the eco-system, conflicts, waste, unnecessary use of energy etc. These materials should be substituted with suitable alternatives, and a lot of research is also needed here, e.g. in the increased use of organic materials that can be grown sustainably and serve as important input for the production industry. However, these materials must also be grown in a sustainable manner and not compete over the space with e.g. agricultural crops.

In many articles I have read on this subject, the economic aspect is always given considerable weight. This is understandable from a historic point of view, given that projects must be economically viable to survive. But it is important to remember that a high investment cost is often necessary to secure the most profitable future solutions, either it is in financial or environmental currency. The way we manage our waste today has severe effects on our environment, which will be extremely expensive to rectify in the future. Because untreated waste from different countries is a global problem, the waste management system of different nations must be restructured and integrated into a global waste management system. This is especially important considering the massive amounts of waste that is filling up our oceans.

The economic perspective seeks to maximize the value derived from every aspect of the process. The most profitable process combined for all the stakeholders, is the best one. The purely environmental perspective on the other hand, seeks to minimize the negative environmental effects of the process. The process that has the smallest ecological footprint is the best one. This is measured by e.g. release of GHG and use of natural resources and energy.

The systemic perspective looks at the social and organisational effects of the process. The process that has the most positive social effects and contributes to systemic integration is the best. Vice versa, if a process is detrimental to the social system, it should be avoided. These effects are measured qualitatively. One example can be the establishment of an automatic waste facility that takes away the livelihood from scavengers. The environmental and systemic perspective will be stressed in this analysis.

The prioritization of goals

When you set out to build a new production system, it is important to make a prioritized list of goals, so that you can rank different alternatives against this list.
This is my suggestion for a list of prioritized goals:

1. First and foremost, the main goal of the circular economy, is to model a production system that gives us control over the use of natural resources, and at the same time denies us the possibility of overexploiting the same resources.

2. The transition must not create conflicts

3. All products should have their own product-cycle, not lifecycle. This means that producers are responsible for the collection and recycling of their products into new products. This maximizes the use of our natural resources, and slows down extraction of virgin materials, because products are constructed to be recycled.

4. The long-term economic effect should create more work for people, and more value-creation

5. In the long run, it must be more valuable for the producers to recycle the product, than to source virgin materials

6. Remove all subsidies on virgin material extraction

7. The transition must be powered by support of governments to the development of industries that use renewable materials.

Reduce, reuse, recycle (3R)

This has become the main mantra of environment organisations in recent years and sounds very logical. The focus of this strategy is to reduce the footprint the production economy has on our environment, and to avoid rapid depletion of our natural resources. The idea is that this will eventually force the producers to produce fewer products of higher quality. This will reduce material and energy usage and waste generation, both by the industries and the consumers. However, this might reduce the production output from the factories, leading to fewer jobs and less revenue. This is an important factor, given the never-ending threat of rising unemployment rates.

Many will argue that employment in production will decline in any scenario, because of the increasing automatization and robotization in manufacturing worldwide. Given this effect, it is easy to see that the revenues from the production in a larger extent will go to the factory owners and investors, contributing to the aggregation of wealth in the hands of the few, as Jackson mentioned. This is not only unjust; it is also harmful to the global economy. From a socio-economic and business economics perspective, it is better to have the largest middle class possible, as they tend to have the highest consumption ratio relative to their income.

Right now, even do we have some recycling; many of our natural resources are being depleted because of our economic system. In order to have a truly sustainable economy, it must be based on our natural restraints. That means that what we use, must be given back in some way. Our usage cannot be bigger than what our ecology is able to produce. That means that our production economy always should maintain a status quo to support the natural processes of our planet. From a moral perspective, we should view ourselves as mere tenants of the earth, and that everything we lend should be returned before we die. To be able to do this, we need a sustainable economic system.

The consumer: Establishing deposit-refund systems

In order to feed this new circular economy with materials, it is essential that the customers return their used products for recycling. One way to do this is to establish deposit product price must therefore include a deposit-refund schemes for as many products as possible, where a share of the product price is given back to the customer when they return the product to, for example, a PRO recycling centre. The deposit share of the product price must be substantial to provide sufficient incentives for the customer to return the product. The company buys back raw materials from the recycling centre for a price that includes the deposit and a cost for the materials, which is highly competitive due to the emerging economics of scale of the recycling centres.

Well-functioning deposit-refund systems have been very successful, e.g. PET bottles and aluminium cans. If the deposit had been higher, the return rate would also be higher. Ideally, there should be deposit-refund systems for all products.

However, this might require a lot of extra work for the shop owners and consumers, and might be difficult to introduce, especially in places where awareness is already low. Furthermore, the deposit must be added to the original price for a lot of products, and since the ratio of the product price must be high, this will make products more expensive, leading to lower sales for the producers. Organic packaging certainly solves a lot of these problems, as the packaging can be disposed of together with the food waste.

This calls for new business models to be developed, especially in the form of expanding the renting and leasing industry, so that people return their products automatically. This will be suitable for more expensive products, such as home appliances, computers, electronics, cars etc., but for food products and packaging it is more challenging. A deposit-refund system for packaging might be applicable, but this requires more research in order to develop functional systems. In any respect, a fundamental goal must be to get consumers to take more responsibility for the products they consume, and to integrate them properly in the circular production value chain.

In order to simplify the sorting process for the consumer, the recycling process for the recycling companies and the production for the manufacturers, and to get the highest environmental effect, the system should be as streamlined as possible, thus effectively preventing leakages.

The following model serves as an example:

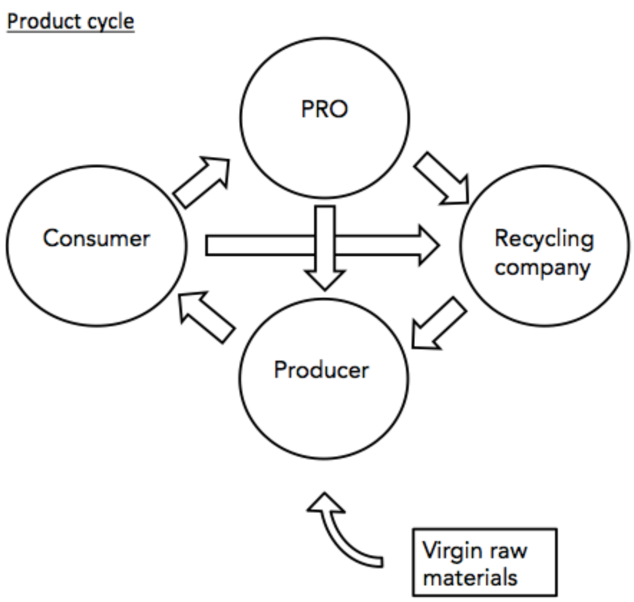


Figure 5. The Product Cycle

In this model (figure 5), which I call simply the Product Cycle, the consumer returns the used resources to the PRO, or directly to a recycling company, which in turn delivers the resources as raw materials to the producer. The producer still has to source some virgin raw materials, but this amount is much smaller than before. As stated before, the use of virgin material should be minimized.

I suggest the following system:

The consumer can buy a total of five different product materials that turns into renewable materials: Organic paper, organic plastic, food, recycled glass and recycled metal. Glass and metal have the theoretic ability to be recycled forever. However, it is difficult to avoid some fraction of dissipation from the production, usage and recycling process. Electronic equipment and hazardous products are returned to the producers. A global waste treatment system with e.g. the same markings for waste bins all over the world should also be introduced. Providing the same system all over the world would make life easier for all consumers who travel.

The Product Cycle will be as follows:

The customer buys products from the store. The price for the product includes a deposit for the material. The used materials derived from the products are sorted by the customer into 5 different containers. The containers are then delivered or gathered by the PROs or the recycling companies, which pay the consumers for the materials. The materials are then processed into raw materials, which are sold to the manufacturers of products. The price includes the deposit and a margin for the recycling businesses. The deposit rate is fixed at a sufficiently high rate, to ensure that the consumer returns the materials for recycling.

At the same time, the government must tax raw materials in order to make them less attractive for the manufacturers. This must be done in a timely and successive manner, in order to allow the production industry to adapt. It is also important to plan the transition carefully to avoid a rapid extraction of raw materials by the suppliers, e.g. the green paradox.

The other aspect I suggest, to increase the customers responsibility, is to apply deposits on all relevant products and materials. This increases the responsibility of customers to deliver their used resources. The deposit must be kept at a certain level to secure that the customers will return the used resources.

Taxing virgin materials to fund renewable materials

First of all, virgin materials in this context are materials that are extracted from nature and have a finite supply. Then comes the question of scarcity. Scarce resources should be taxed higher than abundant resources. The same goes for materials that are extracted in vulnerable and valuable eco-systems, such as rainforests. Virgin materials that do not have substitutes should be prioritized in R&D efforts, in order to develop substitutes as quickly as possible.

Renewable materials are harder to define. One way to do it, is to say that it is material that can be recycled a number of times, e.g. at least five times. This will increase as recycling and production techniques get better. As a consequence this will, theoretically, slow down the extraction of virgin materials. Renewable materials in this thesis will be viewed broadly as materials that can be used again to make new products.

The concept of reuse is important to save resources, but it can also hurt the economic activity if the producers do not adapt their business models. In my opinion, it is a better alternative if companies are allowed to continue to diversify on price and quality as they to today, meaning that companies can offer more expensive products that last longer for the more affluent customers, and cheaper products that last shorter for the consumers with fewer economic resources, or those that just want to buy a cheaper product. This secures a supply for all customers. Companies can also continue to compete on quality versus price. The essential aspect of the new production economy, is that every product that is being produced, is produced with renewable, and hopefully many of them in the near future, organic materials. In order to provide the essential drivers for change towards circular production, governments worldwide should impose a tax on the use of virgin materials. I propose the following virgin material tax function, popularly known as the "Earthsaver Tax Function" (ETF):

$$ETF = f(x) = \frac{\left(1-((\frac{100}{R})^s x^s T\right)}{100}, R \in \left[0,100\right], T \in \left[0,100\right], x \in \left[0,1\right], s \in \left[0.01,100\right]$$

where x is the amount of renewable material used in the production, R is the percentage of total renewable material target level used in production, T is the tax level on profit in percentage and s determines the slope of the function, in other words, the driver behind the amount of tax on a product. ETF gives the tax in percentage for a given producer, depending on the amount of renewable material the producer has used in production. If the target level R is 20 %, and the producer has reached the target level of x = 0,2 = 20 %, then the tax becomes 0. The tax can be deducted from companies' profits at the end of each fiscal year like a corporate tax, requiring strict reporting on the sourcing of different materials used in production and their origin.

The advantage of this function is that it is highly adjustable and can be set to obtain specific goals for the production industry. R can be set to any target level, and T and s can be adjusted to increase or decrease pressure on the producers to accommodate political, economical and technological goals.

The main purpose of the ET is to increase the share of renewable materials in production and the R&D on renewable materials and to decrease waste by turning it into resources for producers and protect finite virgin materials from depletion. The ET should first apply to companies that can easily replace their virgin materials with renewable materials.

Secondary resource prices follow fluctuations in similar virgin material diligently (GWMO 2015). The ETF can contribute to decouple the price fluctuations in renewable materials from virgin materials, by increasing demand for the first, and decreasing demand for the latter.

Instead of funding governments, the tax can be used to fund R&D on renewable materials in order to promote wider use and the continued development of renewable material industries and infrastructure.

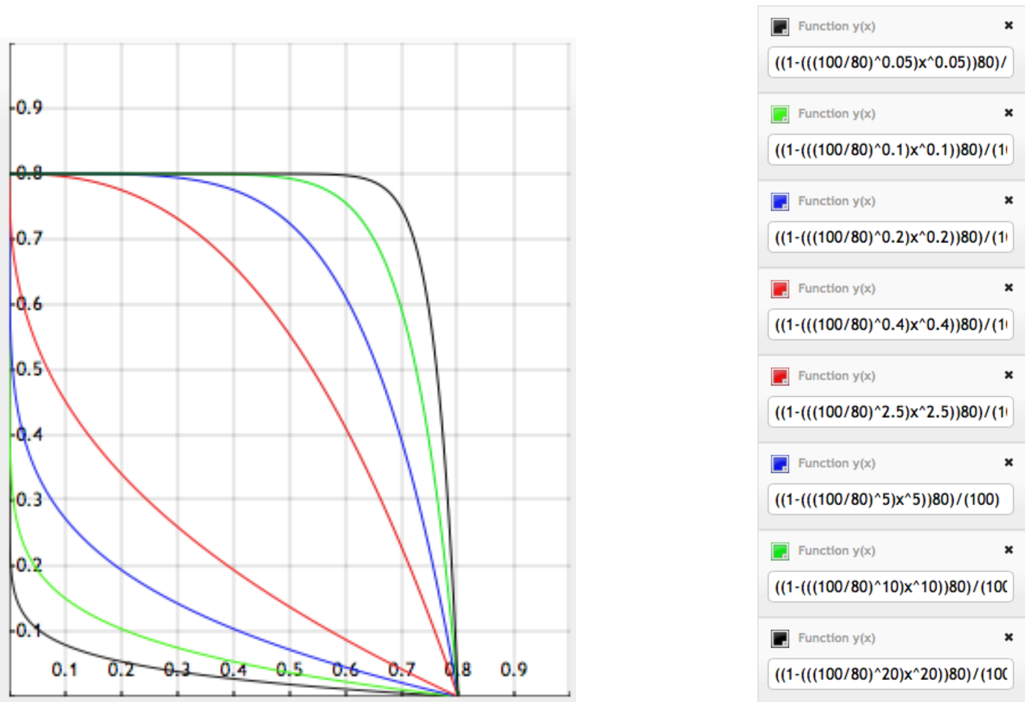


Figure 6: Graph of the ETF. Designed at www.fooplot.com

In figure 6 we see the function with different values for s. The y-axis represents the tax in per cent, and the x-axis represents the amount of renewable material used in the product. Lets picture the following scenario:

We are in 2016, and there is no tax on the use of raw materials. Then the ETF is introduced for all relevant products worldwide, recognised as the lowest black curve in the graph. The ETF imposes a 80% tax on the products that uses no renewable materials in their production, but it is fair, if the producer just adds 5% of renewable materials in the production, the tax drops to 10%. If the producer adds 20% of renewable material to the production, the tax drops to 7,7%. This forces the producers to begin the process of renewable material sourcing, and demand for renewable materials will increase. It is important that the introduction of the tax is carefully planned and thoroughly announced to the producers, to give them time to adapt. R is set to 80% in this example, because the producers are depending on a minimal amount of virgin material in production due to current limitations in technology.

As time progresses, more producers will get used to the tax, and some will perish. That means its time to move to the next curve. The timing of the shifts to a new curve must also be carefully planned, to avoid conflicts, destabilizing of the economy and the loss of jobs. At the same time, it is important that the transition maintains a certain momentum, so the environmental effects are maximized, and the technological transitions are achieved.

On the next curve the tax increases, giving the producers that uses 10% renewable material in their product a 14,9% tax. This is just an example, the curve could get a lower s-value, giving the producers more time to adapt, or a higher one, applying more pressure on the producers to source renewable materials.

As the curve crosses the 0.8-(x^1) line, the function changes its properties. Now it will fast become increasingly more profitable to maximize the amount of renewable materials, giving the manufacturers that does, an competitive advantage. This will lead to “a race to the top”, where the producers that use 80% renewable materials don’t have to pay the ETF anymore. The ones that get there first will obtain a significant part of the market, possibly also because they will be more popular with the customers on behalf of their environmental efforts.

The next question that arises is how the ETF should be implemented. If it were to be calculated on total revenue, a lot of companies would soon default, so a better solution is to tax total income of the company, in order to make an impact. Businesses that have diversified operations could separate out the sections of the company that produces products, so that these sections can be taxed on their income.

Sector	Net Margin
Health Technology	20.9%
Finance	17.3%
Technology Services	16.1%
Electronic Technology	13.2%
Consumer Non-Durables	11.8%
Transportation	9.8%
Consumer Services	9.7%
Utilities	9.2%
Producer Manufacturing	8.4%
Communications	7.4%
Process Industries	7.3%
Commercial Services	6.5%
Consumer Durables	5.9%
Industrial Services	5.0%
Health Services	3.8%
Retail Trade	3.5%
Energy Minerals	2.1%
Distribution Services	1.8%
Non-Energy Minerals	1.2%

Figure 7: The profit margins of 19 major industries in the US (Forbes 2015).

As shown in figure 7, the profit margin for producer manufacturing is 8,4%. Lets say that a company in this industry has a total profit margin of 8,4%. To follow the example above, if they obtain a 5% renewable material share in their sourcing, they are subject to 10% tax on their income, reducing the profit margin to 7,56%. By increasing the renewable material use to 20% the profit margin is just reduced to 8,1% by the 7,7% tax. This may seem like a high price to pay, and it certainly will be, if the producers do not increase their renewable sourcing, especially for the companies with low profit margins. The tax can be adjusted, but it should act as a powerful tool to increase renewable sourcing.

Another point is that the tax should be implemented globally, to involve all companies in the industries that are subject to the tax. This will take comprehensive planning and cooperation between nations, organisations and companies. The discussion on which industries that should be included in the tax reform must take each industry's use of raw materials into consideration, but it should be an ambition that all of the worlds manufacturers are subject to the ET. This is to secure a level playing field for the companies.

Deadweight loss will occur with companies that don't source renewable materials, but it is up to the companies to decide how big the deadweight loss will be. If they want to minimize the deadweight loss, they will have to maximize the sourcing of renewable materials. This will encourage companies to invest significantly and much needed capital into research on recycling.

Possibilities of avoiding the tax

Companies will always try to find ways to avoid taxes. In this section I will discuss some strategies the companies might pursue in this respect.

Some companies raise the price: consumers go to competitors.

Everyone raises the price: If the product has substitutes, the consumers will buy more of those products. If there are no substitutes, or for other reasons, the demand is price-inelastic the producers will probably use this to push the cost of the tax on to the consumers. The tax is therefore better suited for goods that are price-elastic for demand. Researchers also point this out.

Sourcing from other countries: it should be a regional, then global tax, also to avoid company relocation.

Restructuring of companies into e.g. s corporations in order to avoid the tax: all companies, regardless of structure or existing law, must be subject to the tax.

Tax fraud and collusion: this is clearly an issue, and must be dealt with efficiently. Everyone is to report on the sales and purchases and the names of the companies involved in the transactions. External accountants have a special responsibility to control fulfilment. Inspections must also be done consistently in the transition phase, to make sure that companies are complying. Any attempts on fraud or the achievement of fraud should be punished with very high fines or imprisonment.

With that being said, it should be avoided that is happens at all, by establishing a close cooperation between the producers and recyclers, in order to achieve profitable and effective business partnerships that supports the new production system.

Concluding SWOT analysis for the ETF

Strengths	Weaknesses
- Can be adjusted to accommodate needs and developments - Can promote and enable sustainable production - Can replace other more complicated and less cost-efficient policies	- products that have a price-inelastic demand - requires a lot of coordination between stakeholders - requires careful and rigorous planning

- If governed properly, it can create profitable new business models and partnerships - Can lead to substantial cost reductions from reduction in material costs	
Opportunities - can be used to downsize industries - can be used to scale up wanted industries - calls for a multi-stakeholder approach which increases attention and efforts around important goals	Threats - can cause conflicts if not governed properly - can cause shortages if applied to aggressively - attempts at tax avoidance may require extensive monitoring

Table 3: Concluding SWOT analysis for the ETF

The reaction to an increase in supply of virgin materials

In the assessment of a tax on virgin materials it is crucial to include "the green paradox" (Sinn 2009). To control the green paradox, we can introduce a scaling factor for the tax rate in the ETF.

Lets say that the extractor has a net profit π before tax is deducted. The profit after tax, or NOPAT is π_T. The tax rate T then has to be adjusted to meet the changes in production by the extractor, effectively controlling their production.
The adjusted tax rate, T_A, is imposed on those producers that increase production.

$T_A = 1-(\frac{\pi_T}{\pi_1}), p_1 > p_0$, where π_T is the original profit after tax, and π_1 is the new profit after the increase in production, but before tax is imposed. We can also introduce an exponential factor to this equation, making it even more undesirable to increase production, in case companies should have other motivations for an escalation of production. When this is in effect it will make it unprofitable to increase production, because the tax will eliminate the increase in profit. It is only in effect when producers increase production.

An exception is if the demand from consumers is so high and critical, that other suppliers cannot cover it. Then an increase in production levels can be authorized by the governing power.

A controlled transition to create renewable industries

I will now demonstrate how this can be done over time. Imagine an industry where 90% of the material is provided by virgin material extractors, and 10% by renewable material producers. Lets assume further that the two are interchangeable, and that the renewable material is going to replace the virgin material completely in 10 years. If we calculate a 1% increase in demand per year, the 10% renewable material will have to grow to 110% when 10 years have passed. This gives an annual growth rate of 10% for the renewable material suppliers, and an annual reduction rate of 10% for the virgin material suppliers (figure 8).

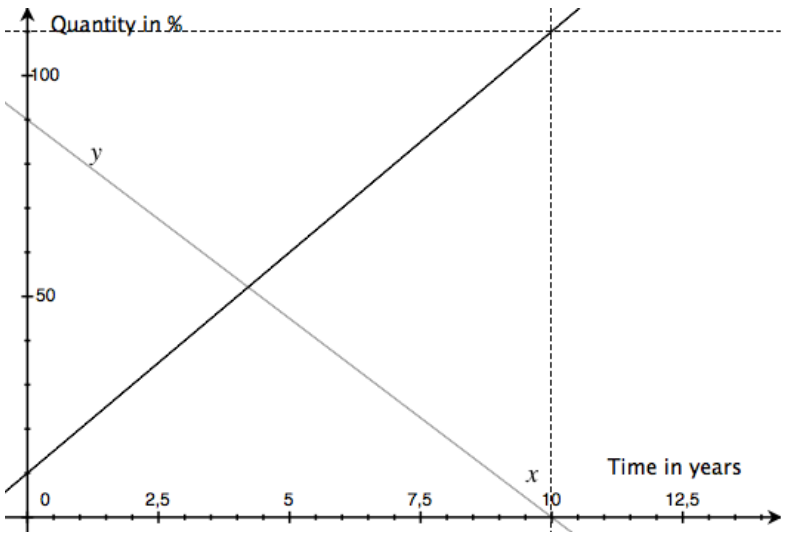


Figure 8: Controlled increase and decrease in renewable and virgin material supply over 10 years

This model can be combined with the ETF and the adjusted tax rate to create a controlled phase-out of the virgin material. I will now demonstrate this, using the oil industry as an example.

In 2013, the oil industry accounted for almost 40% of the global energy consumption, while renewable energy accounted for 3,3% (figure 9).

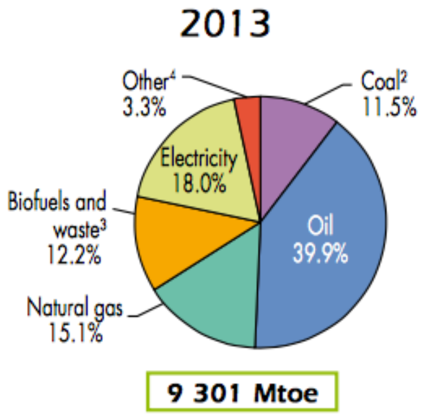


Figure 9. Fuel shares of world total primary energy supply, 3= geothermal, wind, sun, heat, etc. (OECD/IEA 2015).

If we apply the same mechanism as before but over 20 years, and a 2% increase in demand per year, we get the following graph:

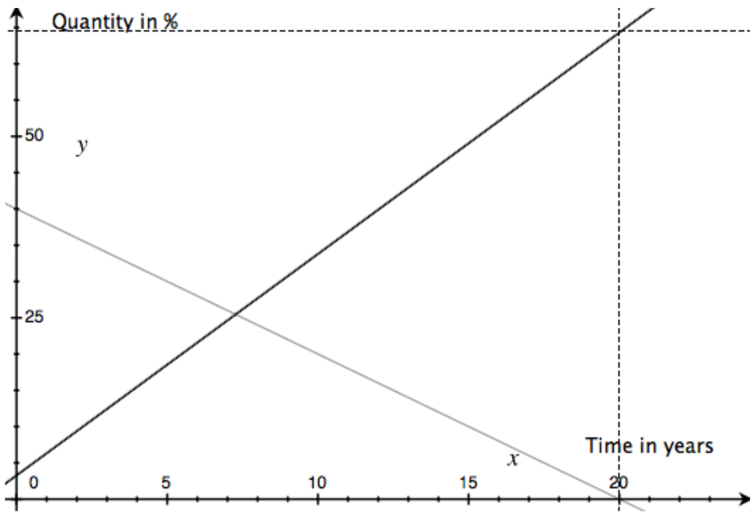


Figure 10: Controlled increase and decrease in renewable energy and oil over 20 years.

$$\text{Total supply after 20 years} = 43{,}3\% * 1{,}02^{20} = 64{,}34\% \text{ of 2013 level}$$

$$RE = 3{,}3 + 3{,}052x$$

$$Oil = 40 - 0{,}2x$$

In this case, renewable energy ends up accounting for 43,3% of global consumption, assuming that the other suppliers remain stable. This linear approach means that renewable energy must have a very high growth rate in the first years, which is difficult to achieve given the technological and financial limitations. We should therefore apply an exponential growth rate to cover the increasing profitability and R&D in renewable energy. This means that the oil industry must have a corresponding exponential reduction rate in order to cover the demand for energy. I have calculated with a 2% increase in demand, giving the following graph:

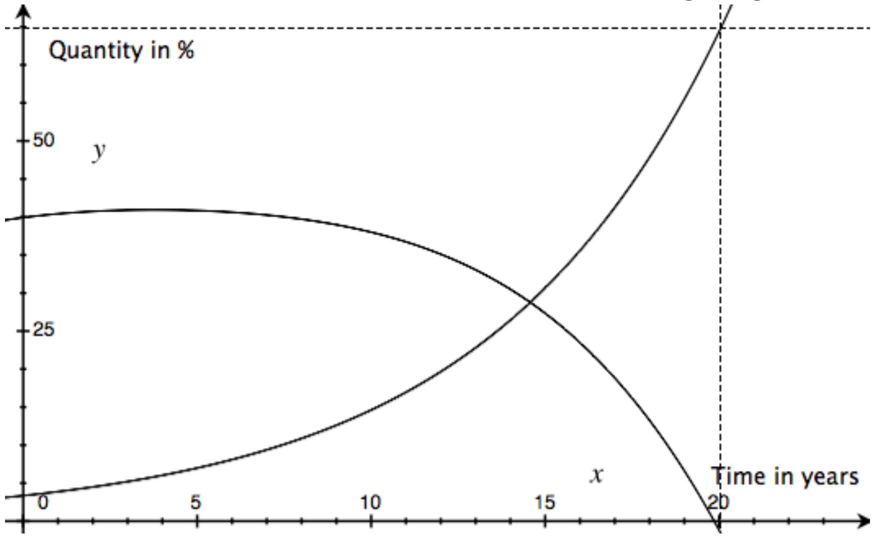


Figure 11: Controlled exponential increase and decrease in renewable energy and oil over 20 years.

In Figure 11 we can see that the exponential curve is better adapted to fit the probable development of renewable energy. Approximately after 14,5 years, supply of renewable energy will be equal to oil in the global market, and renewable energy will replace oil within the next six years.

The function for the increase in renewable energy is as follows:

$$RE_{exp} = 3,3 * 1,1601^{X}$$

The corresponding estimated curve for the decrease in oil supply is as follows:

$$Oil_{exp} = -0,0004x^4 + 0,0066x^3 - 0,1044x^2 + 0,592x + 39,921$$

The oil curve is rising in the beginning; this is because it has to cover the rise in demand that renewable energy cannot cover. This way we can plan the transition phase for the implantation of renewable energy globally. This transition can be further controlled and stimulated by the ET.

The income from the taxes should be given to the oil companies to develop renewable energy systems. This way the tax becomes a type of forced investment, and the oil companies gets transformed into renewable energy companies. This way, a lot of employees do not have to change their jobs, the just change departments, and they get to utilize the competence and knowledge the employees have from oil production. The ET becomes a critical element in this strategy, because it will contribute to the development and construction of renewable energy technology and infrastructure, and provide a political framework for a controlled phase-out of the oil industry. However, this development will require a considerable additional amount of investments, but given this controlled transition, the market should be highly lucrative for investors. The income from the ETF can also be used to fund a long awaited boost in the research on recycling, renewable materials and organic materials down to the nuclear level, as requested by Walter Stahel:

"It is only when we can split molecules and recycle pure atoms, that we can really close the loop and reuse materials forever…today the focus is still on manufacturing" (Nature 2016).

Now, lets apply the ETF to this scenario: let's say that the total annual profit for oil companies a given year is 200 billion USD. We set R to 20%, which gives an ambition that the oil companies should provide 20% renewable energy. The tax limit T, is set to 50 % of the profits, and the slope of the curve is set to 0.2, which gives the following ETF:

$$ETF = f(x) = \frac{\left(1 - \left(\left(\frac{100}{20}\right)^{0.2} x^{0.2} 50\right)\right)}{100}, R \in \left[0,100\right], T \in \left[0,100\right], x \in \left[0,1\right], s \in \left[0.01,10\right]$$

This is shown as the black curve in figure xxx. Lets further assume hypothetically that all the oil companies reach a level of 6 % renewable energy supply. Then the ET becomes 10,7 % and the total income from the tax becomes 21,4 billion USD. Producers are allowed to increase production with a maximum of 3% the first five years to meet the increase in demand, without facing the adjusted tax rate, T_A. In the following years they are not allowed to increase production, unless an energy crisis should emerge. After five years, R is set to 40%, giving a new boost to the increase in renewable energy. T is set to 60% and s stays the same (green curve). After ten years, R is set to 80%, T to 70% and s is increased to 0,3 to stimulate renewable energy further (blue curve). After 15 years, R is set to 100%, T is set to 80% and s is shifted to 2,5, which levies a heavy tax burden on the oil companies that are lagging behind, providing a rapid evolvement towards sustainable energy production (red curve) (See Figure 12).

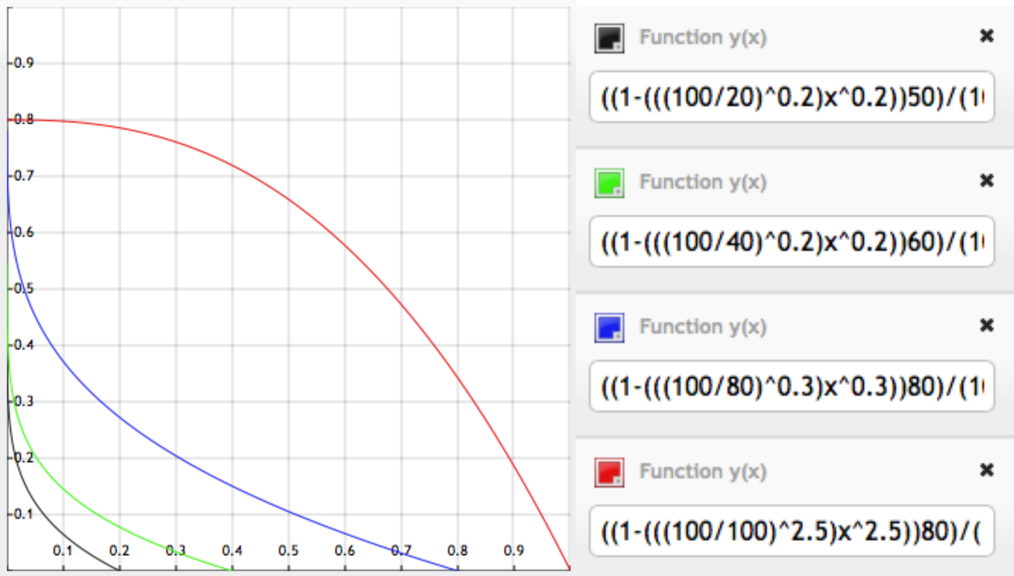


Figure 12: ETF for the oil industry

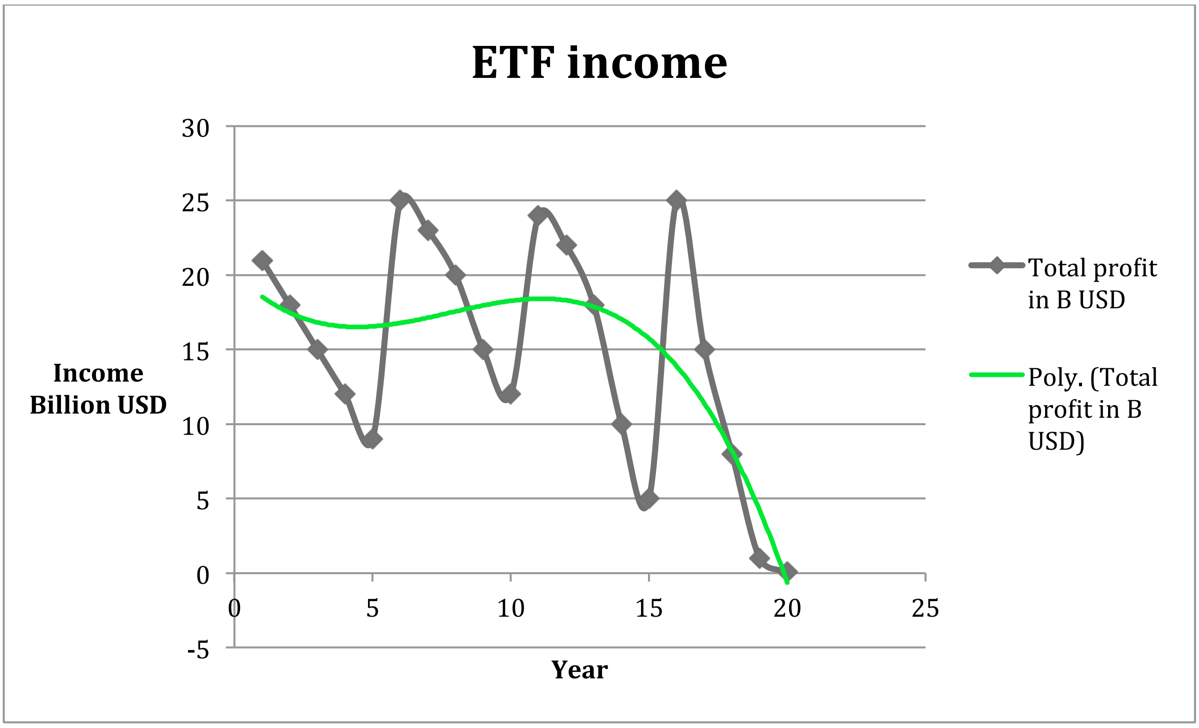


Figure 13: Income from the ET, see Appendix for table

In figure 13, I have made a theoretical example of how the income could be generated from the ET, given the current setup. The green curve shows that the income is fairly consistent over the first 15 years, and after that it drops rapidly, which is consistent with the supply curve for the oil industry. Yet, the income drops consistently in five-year intervals, because the oil companies increase their share of renewable energy, or cuts production. This means that the renewable energy departments must plan their operations accordingly. One possibility is to plan big investments in R&D at the beginning of every five-year interval, when funding is high, and then use the remaining years to expand infrastructure and supply systems.

This is just an example; there are many considerations to be made when governments decide on the setup for the ETF. It is imperative that the tax is not too aggressive and causing default for too many oil companies. This might induce a crisis due to a shortage in energy supply. Still, it cannot be to "soft" either, as it must serve its purpose, which is to boost the transition.

The same setup can be used for any industry that has a substitute industry. E.g. for producers that uses a virgin material as input, the final R could be set to 80%, to significantly decrease the extraction rate for the virgin material.

Conclusion

In this master thesis, I have analysed some policy tools for improved recycling. I found that they have not been effective in the creation of a circular production system, thus confirming my thesis statement. Results form the analysis show that the use of a tax on virgin materials is the most promising alternative, but that this tax must be combined with supporting policies that increases consumer participation and recycling of feedstock materials, in order to be effective in the development of circular production. The use of subsidies is often necessary in order to strengthen the market share of new technologies such as renewable energy, but these subsidies should be used with caution to avoid the onset of "the green paradox". Policy tools in general should be used with caution, as they can cause market distortions and inefficiencies. They must have a clearly and narrowly defined goal in order to reach their desired effect; if the ambition of the policy tool is to widely defined, it will be very difficult to measure its effect. Additionally, there will be need for waste management systems that are effective in handling an increasing amount of waste globally, but at the same time does not create barriers for the establishment of circular production.

Based on these findings and the analysis of the studies of other researchers, I have suggested a strategy for the transition into circular production in which I have developed policy tools, specifically the Product Cycle, Earthsaver Tax Function, Adjusted Tax Rate and the Circular Enabling Resource Management System. These policy tools can be used by governments to empower a transition into circular production. However, they should be used with caution and careful planning, and most importantly, in close cooperation with the industry itself, in order to facilitate a smooth transition into circular production.

I have tried to be creative and develop both conceptual and mathematical tools that can support technological and economical endeavours. However, these are based on just five months of research, and needs to be developed further. There are also a lot of questions related to the use of these tools that I have not investigated in my thesis.

Future research

The development of these policy tools is the result of my conceptual study, and there are still a lot of questions that needs to be answered, e.g. what effect the ETF has on competing industries, future prices, consumer preferences, product quality etc. I hope these ideas can provide inspiration for future research, both for the development of this model or completely new ones. I expect my proposition to be criticized, but hope that it also will be thoroughly scrutinized and developed further, in order to change current production practices worldwide.

Future research should first and foremost focus on the development of renewable technology and materials that can replace virgin materials in the global market. Researchers should also try to find efficient ways to ensure a swift transition into a circular production economy, by exploring other possibilities, including different business models, other economic systems and altered environmental policies.

Appendix

Year	Total profit in B USD	Total ET in B USD
1	200	21
2	210	18
3	220	15
4	180	12
5	200	9
6	210	25
7	190	23
8	180	20
9	170	15
10	180	12
11	160	24
12	140	22
13	140	18
14	150	10
15	130	5
16	100	25
17	70	15
18	50	8
19	20	1
20	1	0,1

Appendix 1: Table for figure 13

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