Chapter 11
Is Circular Economy a Magic Bullet?

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11.1 Introduction

Humanity faces challenges in many areas in our efforts to achieve sustainability. There are biological and technical challenges but also social and economical challenges. How can our socioeconomic systems develop to better manage resources in order to serve humanity and preserve ecosystems for a very long time? Our inability to cooperate in solving our common threats and mismanagement may be the most difficult challenge. In this chapter we examine the *pros* and *cons* of circular economy. CE includes several good ideas and intentions; the challenge is to make it work in a complex market economy with a large number of individual decision makers with differing interests.

The problems we face concerning the environment and increasing resource scarcity have, to a large extent, grounds in the prevailing linear economic system (Jackson et al. 2014; Wijkman and Rockström 2012; EMAF 2012). Already in early reports, such as 'Silent spring' (Carson 1962), The economics of the 'Coming Spaceship Earth' (Boulding 1966) and 'The Limits to Growth' (Meadows et al. 1972) the consumption and production system was criticized for having a tendency to waste natural resources, to accumulate and spread waste and to assume existence of abundant natural resources. The current economic system can be described as a linear system following the logic of "take, make, waste" in regard

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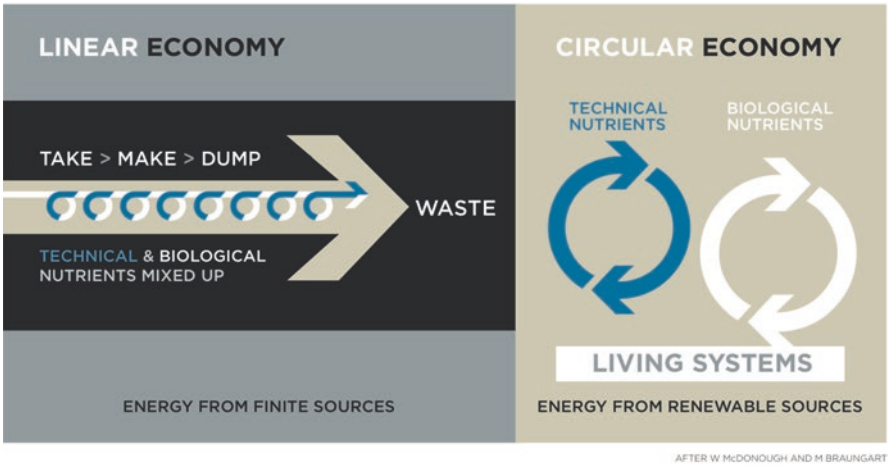

Fig. 11.1 Overview of circular economy (http://www.ellenmacarthurfoundation.org/circular-economy/circular-economy/rethinking-the-economy)

to natural resources. There is an obvious need for rethinking how our systems ought to work.

The fundamental idea in CE is to reduce resource use and waste of natural capital by building on the idea of nature's waste free cycles which are fuelled by solar energy. Circular economy (CE) has been suggested as a sustainable alternative for continued human and environmental welfare.

> The circular economy model uses the functioning of ecosystems as an example for industrial processes, emphasizing a shift towards ecologically sound products and renewable energy (Kopnina and Blewitt 2015, p. 21).

In this chapter we describe what proponents suggest and try to analyse what is new and its relation to sustainability. There is also a critical examination of the possibility to implement the ideas of CE.

Figure 11.1 illustrates the difference between a linear and circular economy.

11.2 The Concept of and Growing Interest in Circular Economy

In the 1960s and 1970s researchers such as Kenneth Boulding and Walter Stahel started arguing for the need of connecting the economy to the cyclical ecological system and the need to create an economy based on a loop system, a self-replenishing economy. However, it was two environmental economists, Pearce and Turner, who were the first to coin the term 'circular economy' in their writings of "Economics of natural resources and the environment" in the early 1990s (Li 2010).

Stahel's ideas on an economy based on a loop system were later picked up by the chemist Braungart and the architect McDonough that successfully launched the concept of cradle to cradle (C2C) in 2002 (Braungart and McDonough 2008). Stahel then further coined the term performance economy, distinguishing "between producing performance, selling performance (instead of goods) and maintaining performance over time (the circular economy)" (Stahel, 2015-05-17, personal communication).

As used today, the concept circular economy is a synthesis of the above mentioned and several underlying ideas that are put together within the framework of CE. It includes for instance concepts like cradle-to-cradle, performance/sharing economy, biomimicry and insights from industrial ecology (EMAF 2013, 2015). Like many other innovative solutions CE is in fact not new but rather reintroduced and reframed. For a strategy to be lucrative and gain popularity, old ideas are presented in a new way as a progressive intervention (Kopnina and Blewitt 2015).

Research and development work within CE is at present mainly driven by more or less business oriented organizations. The most known organization is The Ellen MacArthur Foundation (EMAF) which was formed in 2010. World record sailor Ellen MacArthur's analogy of the limited resources on a small sail boat and the limits we have on earth mirrors Bouldings (1966) rhetoric's of spaceship earth. EMAF re-actualizes old theories in a new concept and has successfully taken on the task to gather scientists and industry to spread the message of resource constraints and possible solutions found within CE. "*EMAF believes that the CE provides a coherent framework for systems level re-design and an opportunity to harness innovation and creativity to enable a positive, restorative economy.*" (EMAF 2015). The Ellen MacArthur Foundation is supported by a group of "Global Partners", big international corporations. The Ellen MacArthur Foundation and their work with CE is also supported by the World Economic Forum.

There has long been a perceived antithesis between financially and environmentally sound decisions. Circular economy has a strength in showing how these different goals within a business can complement and even reinforce each other in a world with scarce resources. When availability of many non-renewables (including metals, minerals and fossil fuel) cannot keep up with the rampant consumption demand and the regenerative capacity of renewables (such as land, forests and water) becomes strained to its limits — continued dependency on scarce natural resources exposes a company to serious risks (Rydén, 2015-02-03, personal communication). Thus, taking control over the resource flows back into the business is favourable for both environmental footprints and financial control.

The EU has recently launched a "Circular economy package". One reason why EU politicians jumped on the CE train relatively quickly in comparison to other suggested sustainability solutions could be because the economic case was perceived positive from the beginning. Some early calculations indicate economic growth and employment as a consequence of the growing circular business sector (EMAF –; Wijkman and Skånberg 2015).

> This is the future for business. ... The circular economy will not only enable businesses to tap into new sources of value, but help forge resilient markets and supply chains capable of delivering long-term sustainable prosperity. … The World Economic Forum, Ellen MacArthur Foundation and McKinsey suggest this circular transition represents a $1tn opportunity for the global economy. As such, it presents a significant opportunity for businesses and consumers alike to move away from our traditional linear 'take, make, and waste' economy towards a circular model. (Perella 2015)

The basic ideas of CE have been around since the 1970s and have been part of many discussions since that time. However, it seems to have been too early for the ideas to become generally accepted. It takes time for all revolutionary ideas to mature and for society to be ready for them. Webster thinks that now might be the time that society is ready for the circular economy. There are at least three reasons that may speak in favour of a breakthrough. The first reason is the resource scarcity, the second is that information technology is advanced enough to keep track of material flows in different places of the loop and third, there is a shift in consumer awareness and behaviour making us more willing to prioritize access to a product or service rather than ownership of a specific item. Ken Webster (in EMAF 2013, p. 15)

11.3 The Main Components of Circular Economy

> A circular economy has an aim to regenerate the capital, no matter if it is financial, man-made, human, social or physical and have production and transport systems that run on renewable energy. (Cradlenet 2015-04-01, our translation)

CE proponents claim CE to be a new paradigm for industry since it aims at regenerating ecological, social and economic value resulting in effectiveness that improves the state of the environment and even goes beyond sustainability (Kopina and Blewittt 2015, p. 238).

Each product produced in a circular economy should be designed so that the biological and technical components (types of material) could be easily separated and re-circulated in the system in accordance with cradle-to-cradle principles and focuses on effectiveness rather than efficiency. It also builds on ideas of performance economy with new business models that focus on selling services instead of products to reduce the resource use (Wijkman and Rockström 2012, p. 166).

Cradle-to-Cradle (C2C) is one of the main building blocks in CE. The C2C theory (Braungart and McDonough 2008) claims a natural science background and treats humans as a biological being at a "species" level as other living things, as opposed to, for instance, economic man that treats humans as something outside or beside the natural ecosystems. From this point of view it is clear that the misuse of natural resources is catastrophic for earth and its living systems as well as for future human life.

In the report *World Commission on Environment and Development* (1987) the link between eco-efficiency and sustainability was articulated. This prevailing environmental and sustainability approach of efficiency has, within C2C and CE, been

criticized for only focusing on making industry less bad by reducing, avoiding, minimizing, sustaining, limiting and halting. Rather than actually doing things good from the beginning — i.e. effectiveness by restructuring the production system so that it focuses on having a positive impact as opposed to only having a less negative impact. Braungart and McDonough (2008) claim that C2C focuses on eco-effectiveness rather than eco-efficiency.

McDonough and Braungart (2013) argue that the eco-efficiency strategies used for sustainability goals today, are stretching the line but still support the linear production system. "That Reduce, Reuse, Recycle and Regulate are not good enough and puts a negative tone to being environmentally friendly" (Braungart and McDonough 2008, p. 53–61). *Reduction* is indeed needed but it is nevertheless not stopping the depletion and destruction. *Reuse* is only good if the product being reused is not toxic and not releasing toxins during its use. This is true also for reuse and recycling within CE. *Recycling* is in most cases down-cycling; when products that were not designed to be disassembled into different materials will be low quality materials after recycling and might also need additional chemicals in the process to give the sought properties and qualities and thus add toxins to the system. Laws and *regulations* are also claimed to often be an end of pipe solution aimed at minimizing emissions for instance but do not at the same time reward innovative problem-solving (Braungart and McDonough 2008 p. 61). It could even be more dangerous to, for instance, ban one single toxic material in products since it might lead to substitution with not yet banned materials that are even more toxic. This is not common in the real world; however, similar but slightly less dangerous chemicals are often used when one chemical is banned and heavily regulated.

However, they make clear that efficiency can be good, but only when implemented as a tool within a larger, effective system that intends overall positive effects on a wide range of issues — not simply economic ones. It is also seen as valuable as a transition strategy to help current systems to slow down and turn around (Braungart and McDonough 2008, p. 65).

C2C can be seen as an alternative design and production concept, focused on eco-effectiveness; the development of products and industrial systems that maintain and enhance the productivity and quality of materials through subsequent life cycles (Braungart and McDonough 2008). The concept of eco-effectiveness means working on the right things — on the right material, products, services and systems — instead of making the wrong things less bad (Braungart et al. 2006). Eco-effective designers expand their vision from the primary purpose of a product or system and consider the whole. The designer team is supposed to think through what the goals are and potential effects, both immediate and wide-ranging, with respect to both time and place. And what is the entire system — cultural, commercial and ecological — of which this production and product will be part of (Braungart and McDonough 2008 pp. 81–82)?

These ideas applied to our human built processes are the base for three principles in C2C, and CE:

1. *Waste = food*, i.e. that the residue of one process is used as feed/resource in the next process. Nature's nutrient cycles comprise the biological metabolism and the design of technical metabolism mirrors them.
2. *Celebrate diversity*. Ecosystems are complex systems that thanks to diversity enhance a greater adaptability and resilience.
3. Use solar income, the only continuous source of energy.

In the natural cycles of the Earth systems the residue or waste from one cycle becomes nutrients for others. Historically, humans lived more within and connected with nature and the natural cycles at all levels. Humans acted as part of the natural system and respected it in a different way to make sure human waste, both sanitation and made things, became part of the cycles when discharged. Since industrialization and with urbanization, we have, however, distanced ourselves more and more from nature and created non-natural linear flows, cradle to grave, as well as products with hazardous waste as a common side-effect (Braungart and McDonough 2008, p. 93).

Resources and materials can be described as biological or technical, i.e. man made. Biological nutrients can be useful to the biosphere, while the technical nutrients can be useful for what is called the technosphere, the systems of industrial processes. These materials are often mixed however and are, therefore, difficult to re-circulate. Braungart and McDonough (2008, p. 93) points out that we have developed an industrial infrastructure that ignores the existence of nutrients for either kind and have created hybrids of materials that do not fit into either the organic or technical metabolism because they contain hazardous components, and are wasted or lost since the materials cannot be separated after their use (Ibid p. 98–99). Following the principle of waste equals food at design level, producers can make sure that the waste from one product can be reused as nutrients for new products for themselves or other producers in their network.

Ken Webster (2013) emphasizes that diversity increases the resilience of a system. Thinking too much of efficiency implies streamlining processes which will on the other hand result in brittleness of the system since there are so few alternatives if one thing breaks down. Thus, instead of focusing on partial processes, we have to build a system that sees the value of all different flows and the importance of optimizing the whole system and not its parts. Having a built in diversity gives a possibility to adapt to new situations when needed and thus increases the resilience.

In C2C it is expressed that sustainability is local and that respecting diversity includes adapting to the local environment and conditions — regarding material and energy flows as well as local customs, needs and tastes. (Braungart and McDonough 2008 p. 123). Using local sourcing also avoids the problem of bio-invasion — when transfer of materials from one region to another introduces invasive non-native species to fragile ecosystems (ibid. p. 125) — and thereby protects the biodiversity.

Earth's source of incoming energy is the sun, and thereby the fuel for all biological processes. Historically and indirectly even for fossil fuels. The sun is also the motor for other renewable energy sources such as wind and water power. Using different renewable sources of power is seen as an important part of CE (Preston 2012).

Performance and sharing economy is another important part of the CE thinking. One reason to focus on performance rather than commodities is to make it logistically possible for producers to take back and keep technical products in the loop. To ensure that this happens, the notion of product as a service is an important concept since the ownership for the resources then is still kept by the manufacturer (EMAF 2012, p. 111). Another reason is that creating a circular economy implies a shift away from ownership to a new model of collaborative consumerism. This part of CE focuses both on new business models, for example Uber, and product innovation such as driverless cars. The thought is that a shift in consumer mind-set to embrace access to service rather than ownership will hopefully lower demand on new products. Selling a service or performance of a product instead of the physical product would result in a more resource efficient system (Stahel 2010). It is far from obvious that this will be the result in a growing economy, due to the so called rebound effect. Those who had no access before may get it but those who had access will keep their ownership and total consumption would increase.

Sharing economy or collaborative consumption are actions that can be organized between private persons and do not have to involve businesses. The ideas are based on the notion that the ownership of things is replaced by access to the product by "schemes of sharing, bartering, lending, trading renting and gifting" (Botsman and Rogers 2010, p. xv). The philosophy of sharing is based on trust which in itself creates meaning to the user beyond the benefit the product provides (Axelsson 2014, pp. 48–52). This effect and the possibility of new community contacts, add an extra positive aspect to this type of consumption.

Regarding performance economy business models, the same examples are used today as those shown to be revolutionary 20 years ago within the Natural Step (personal communication Markus Larsson). For instance Xerox copying machines, car sharing and Interface flooring. Leasing was promoted as *the* sustainability solution back then as well, which it turned out not to be. Maybe the market and consumers were not ready for it. It will soon show if we are ready now or if we are still too deeply rooted in ownership thinking. Another reason for not succeeding might be that it required complicated administration; administration that is now said to be facilitated by smart techniques. Parts of the solution are there, and have been for a long time, but the development is slow and meeting resistance (personal communication Markus Larsson).

Biomimicry is the methodology of mimicking nature, at all scales. It is defined as "an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies" (Benyus 1998).

Biomimicry relies on three key principles (EMAF et al. 2015, Orru 2014-12-17):

- Nature as measure: using ecological standards to measure and judge the sustainability of innovations and designs.
- Nature as mentor: look at nature with the notion of what we can learn from her rather than what we can extract and gain from resources.

- Nature as a model: studying natural systems to have as a model for forms, processes, systems and problem solving strategies.

An example could be to construct buildings with natural ventilation and solar heating inspired by termite colonies or smaller challenges as of how to design and construct a water-repellent material with leafs or bugs as models (Benyus 1998). Building new designs to mimick nature could also imply going back to using techniques that were abandoned for more modern and seemingly efficient methods and materials, for instance (re-)start using soil and plants as a cooling and heating ecosystem on roofs (Braungart and McDonough 2008 p. 83).

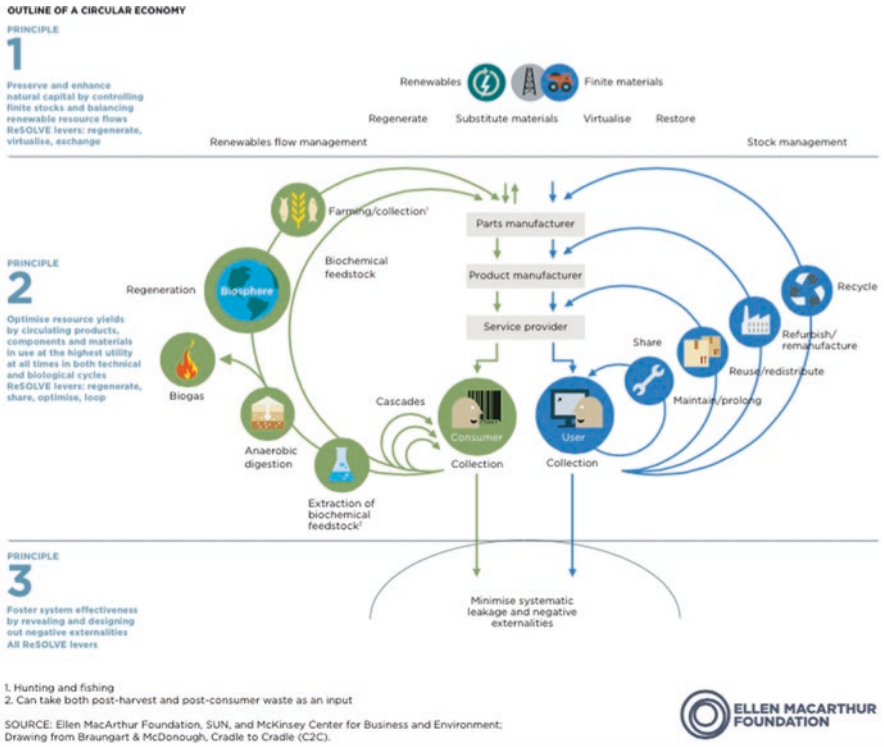

Fig. 11.2 Circular economy with its two systems of nutrient cycles (EMAF et al. 2015) (ReSOLVE refers to: REgenaerate, Share, Optimise, Loop, Virtualise, Exchange. See the full report for further explanation – EMAF et al. (2015) Growth within: a circular economy vision for a competitive Europe)

11.4 Outline of a Circular Economy

Given the different underlying concepts, a circular economy is restorative and regenerative by design, and aims to keep products, components and materials at their highest utility and value, at all times. The concept distinguishes between technical and biological cycles (EMAF et al. 2015). Key characteristics of CE thinking is a holistic approach and systems thinking (Ann-Charlotte Mellquist and Lise Lyngfelt Molander, personal communication).

Figure 11.2 illustrates how biological and technical nutrients should be divided and kept in separate loops in order to maintain high quality and make effective and efficient circulation possible. *Biological nutrients,* to the left, are products or materials designed to be part of the biological cycle — after its product life returning to the natural environment and being consumed by animals or microorganisms (Braungart and McDonough 2008, p. 105). *Technical nutrients*, to the right, on the other hand are materials or products that are designed to go back into the technical cycle, i.e. into the industrial metabolism from which it came (Braungart and McDonough 2008, p. 109). The arrows, or cascades, illustrate that the shorter and smaller the loop obtained, the higher the value kept in the resource and with less addition of energy and other resources to keep it circulating. World Economic Forum discussions on CE further emphasizes the power of; (1) the inner circle, keeping the smallest loops possible, (2) circling longer, (3) cascaded use across industries, (4) pure/non-toxic/easier-to-separate inputs and designs.

11.5 Is CE a Paradigm Shift?

The famous quote by Albert Einstein "*We cannot solve our problems with the same level of thinking that created them*" is an often referred quote in sustainability contexts. Meaning that we have to rethink the whole system that has created the unsustainable system that got us into the problems we have today. Ellen MacArthur and others express that CE is a paradigm shift, a new way of thinking, which can solve many of the problems humanity is facing.

However, it is difficult to see CE as a paradigm shift since most of its components are not new. For instance much of the knowledge needed for sustainability is old knowledge within agriculture and forestry that we have not managed to implement in our modern societies. Within agricultural science the concept of circulation has been around for a long time. When Sustainable Development was put forward at the end of the 1980s, land as a production factor was re-lifted, but it had been an essential part of the economic theory in the eighteenth and nineteenth centuries. It was during the era of neoclassical economic thinking that land, and nature, was dropped as a major production factor. On a macro level it is a rediscovery of the wheel — the circulating wheel. Agricultural and forestry science is about efficiently creating welfare through resources from agricultural land and forestry land. This

perspective moved out of focus during the twentieth century when cheap fossil energy made us less dependent on the production factor land (which in economic theory is synonymous to the ecological dimension of the economy) and the emissions were mostly on a local level and generally without a great influence on welfare. Current photosynthesis was substituted by historical photosynthesis saved in fossils. Hellstrand (2013, 2015) and Hellstrand et al. (2009, 2010) analyse this in detail. Rather than seeing CE as a paradigm shift it can be seen as going back to how the economy worked in the eighteenth and nineteenth centuries.

11.6 Circular Economy, and Business Influence

The Circular Economy movement of today is mainly business driven and business focused. Even though many concepts within CE are older, the reframing and merging of them into one CE concept has managed to reach new target groups that were not interested in environmental problems before. Today, CE is very business focused and that's a good thing, since this target group lacked arenas to discuss sustainability innovation and transition. In many businesses today, sustainability is foremost about communicating a result of sustainability on the last row, rather than actually working sustainably throughout the business. Society is in general, punishes business activities instead of encouraging the ones that have a sound base. The industry is not to be seen as "the bad guy", it is politics that has to set the boundaries.

In 2015 a report to the Club of Rome was released, *The Circular Economy and Benefits for Society* (Wijkman and Skånberg 2015). This report, as well as the earlier mentioned report by EMAF, also shows significant possibilities of financial and growth opportunities as well as reduction of carbon emissions and increase in employment. A reason for expressing CE more in terms of financial gains, employment and growth opportunities is to get politicians onboard since politics can help a great deal in taking CE requirements further. This can be done by making sure the questions are formulated so that they become politically relevant to gain impact (personal communication Skånberg).

11.7 Potential — Real or Imagined

There are several crucial issues for the possible success of CE; such as its relation to the present economic system, the imperfect price mechanism of natural resources and the role of government. It has been argued that globally the potential benefits could be as large as $1 trn, mainly because virgin natural resources are more energy demanding than those that have been recovered. Also, it has been argued that business can shift to CE voluntarily since it can materialize the potential benefits and actually increase profits simultaneously by reducing the environmental burden of

our production and consumption system. It sounds like a *panacea* or magic bullet — is it really?

Even if many of the CE ideas are not new and more going back to the initial meaning of economy — to economize with resources — they may be new in the way it combines knowledge from different fields and its potential to make an impact on the business and political arena. Thus, if picked up by businesses at a large enough scale, it might lead to a paradigm shift in practice.

The present form of market economy may, however, become a hindrance to success. Maximizing enterprise profit is not the only goal, as is assumed in neoclassical theory. It may already be a problem if a satisfying behaviour is assumed to be the target of business. Satisfying behaviour enables economic sustainability, i.e. revenue is larger than costs in the long run. One important condition is that someone is willing to pay for the goods or services that are produced by enterprises following CE principles. In a market individuals react to knowledge or perceptions about existence and quality of goods and services as well as of their prices. Collective interests they may have as citizens, such as quality of the environment are not expressed very much on the market where individuals express more self-interest. Such issues are better managed through political processes.

Some people are so wealthy they are not affected even if prices are doubled or more, i.e. in practical terms they have no budget restriction. People with such wealth are a minority, albeit growing in numbers over time. They have practically no incentive to save material if prices increase. Inequality is, therefore, not only a problem of fairness but also something which makes it more difficult to reach sustainability. The other resource and environmentally important side of inequality is a pressure on some local natural resources caused by extreme poverty. CE theory and principles lack solutions for social sustainability and addressing these inequity problems.

As relative scarcity gradually becomes a problem, increase in prices of natural resources is one type of incentive to use materials wisely and reuse in order to conserve natural resources as a fundamental part of CE. As natural resources such as minerals are extracted the remaining reserves with high concentrations and that are easy to extract will become smaller. Expected future prices and thereby the value of the remaining resource of equal quality will increase. Owners of such resources should demand a higher price since it is more profitable to keep the resource in the ground and sell it later.

This is in theory, and it may not be the way the real world economic system works. Experience so far is that as long as such resources can be extracted prices do not change in a systematic way. Prices on non-renewable natural resources have been surprisingly stable over time, with some exemptions, e.g. copper. For fossil oil the long term price trend has been decreasing in spite of the fact that we have used a large fraction of existing reserves and we can observe signs of "peak oil". Prices have increased in periods of severe conflicts in the Middle East, including creation of OPEC. This has been as a reaction to lack of supply in the short run rather than increasing long run scarcity. There was an increase in prices for oil, and to some extent for natural resources generally, in the new millennium with a dramatic drop during the 2008 crisis. This trend was broken in 2014 and the prices since then have

gone down. Especially, fossil oil prices are very low compared to the rest of the period after year 2000. Overall, the instability has increased over time since 1930.

The lower prices today seem to be caused by a combination of factors affecting supply and demand. Regarding decreased demand factors such as the following examples play a role; (1) stress in the economic system in North America and Europe, (2) a number of policy measures within different policy-areas within the field of natural resource management as well as in totally different policy-areas, for instance trade-measures in the EU and Russia due to the conflict in Ukraine, or changed policies regarding foreign trade for various commodities in China and (3) international conflicts reducing demand from affected regions.

Regarding increase in supply, possible factors are; (1) change of EU-policies related to the common agricultural policy affecting the system of milk-quotas, (2) increase in supply of fossil fuels due to new technology making non-conventional supplies profitable to utilize and (3) the agreement between Iran and the USA giving Iran access to the global fossil fuel market again. The examples above do not represent a complete list, but a few examples of factors affecting prices of natural resources. It cannot be excluded that beneath these factors there is another and new trend operating that indicates an increasing natural resource scarcity to the global economy (Hellstrand 2015).

The fast increase in the use of photovoltaic elements is due to technological innovation in combination with high prices on fossil oil during the last 10 years. The search for alternatives is stimulated by the threat of climate warming.

There is likely to be dramatic price increases on some natural resources in the future when it, due to scarcity, becomes difficult to supply the markets with demanded quantities. This may however be much later than is needed to stimulate CE in the form of cradle-to-cradle design.

The possible role of government is an important issue in relation to CE. In some of the literature the role of government is played down with expectations that business will see potential benefits and by themselves do the right things. Others are aware of the need for governmental policies. We are clearly in favour of the latter view. There is no socioeconomically advanced society that does not have a functioning state sector. Also, the socio-economic systems that score highest on welfare indexes of various kinds are the Nordic welfare states that have relatively high taxes and a relatively large state sector.

Wijkman and Rockström seem to be aware that there is a need to supplement the ideas in CE with regulation.

> Today we need to couple the advantages of an open and globalized market economy with regulations that enable consumers and producers worldwide not only to be more efficient in general in their use of natural resources but also effective — that is, to do the right things. Wijkman and Rockström (2012, p. 169)

There are problems in combining a market economy operating over national boundaries with a number of nations having unique sets of regulations. Global enterprises can even put pressure on small nations not to regulate by threatening to move to other countries. The examples of effective and well working international regulations in the area of environment and resource conservation are few despite the large need and many efforts made.

The possibility to collect and reuse materials in a safe way is crucial for the functioning of CE. Today, in some countries the level of recycling reaches 50–95% for some material flows. There is no doubt that this could be achieved in most well organized countries and with a few more flows as well. There is, however, a limit to how many different fractions consumers can separate waste flows into. In the cases where recycling is successful, there is policy to support it. Deposit-refund systems are one type of system; where consumers pay a fee when they buy a commodity or packaging/container, e.g. a glass bottle, and are refunded when returning the commodity or packaging/container. Such systems could be organized voluntary by the provider of the goods but are normally a result of legal demands.

Another solution is to put legal demands on producers to be responsible for the goods when they enter the waste stage. This is used in Sweden and the result is that producers organize a collective system to collect, transform and reuse the material. This solution does not give incentives to individual producers to make sure the purity of materials used is such that there is no danger in reusing the material in other uses where quality demands are higher. To achieve that there is a need for responsibility for individual retake of "their" material, but that would be much more expensive in terms of organization and transport. This is not necessary for homogeneous material flows where there is little risk of content of dangerous chemicals. There is, however, a risk that dangerous chemicals can be spread in the environment causing health problems if material streams are not "clean".

Once a company has the material in a more or less pure form there may very well be profits in reusing it. What is the incentive for consumers to sort waste and return the things they do not use to the company which has sold it?

It would take a lot of effort to return each commodity to the seller or producer of that commodity. If it is collected in a mixed stream there may be a need for sorting which might be expensive in terms of labour time and it may still not be safe. The number of different commodities in circulation in a modern society is enormous. Also, for an individual consumer there are many companies that they buy from. For large and relatively homogenous flows, such as wood and cotton or iron and aluminium, the possibility to organize collection and reuse is good. For more complex commodities this becomes much more difficult to do.

For flows of biomaterial, which of course should be kept separate from industrial flows, it is important to keep the purity on such a level that they could be safely returned to and used in the various forms of bio-production. The most critical issue may be the concentration of dangerous chemicals. There are other impurities that are not dangerous for soils or bio-production.

In some cases, the issue is not that of dangerous chemicals but rather the mere quantity of flows, e.g. various forms of plastic. Plasticisers, e.g. phthalates, or repellants, e.g. perflourated carbonates, make the plastic into dangerous commodities, but even without such additional substances plastic poses some danger to the environment. It will be very difficult to make consumers not demand the products with special qualities and properties that depend on the use of some dangerous chemicals, if the decisions are taken individually on a market; and for the producers to stop using the same chemicals if there is profit to be made.

It is very unlikely that the needed systems for reuse of materials will appear without the influence of policies to give consumers incentives to do the right thing. The potential of $1 trn is more a theoretical maximum than something that could actually be reached in the real world. Creating and enforcing a policy has a cost that must be included in an economic calculation. Generally, a policy for increasing the costs of using energy based on fossil fuels is a must in order to give incentives for substitution and reduced energy use. Higher prices on fossil fuel would have many implications for resource conservation in other fields as well.

The business model of leasing or selling services instead of products is said to give incentives for the businesses to keep the products longer but it may have a negative side. There is a risk of increased power for businesses if we at a higher degree buy services and performance rather than products. If companies own durable goods in our homes, inventories at other companies or public places, people tend to become more dependent; thus losing power. Also, there is a risk that centralized power in digitalized sharing platforms will create monopoly which is less flexible and creates new power structures. This may have negative social impacts. The digitalized sharing platforms may create societal benefits and profits for the owners of the platforms but give little gains for the other actors on this market.

A policy for increasing the costs of using energy based on fossil fuels is a must in order to give incentives for substitution and reduced energy use.

CE may not be a *magic bullet* or *panacea* but it involves several good ideas that can be used to improve our society. The challenges to reach sustainability may be more difficult to overcome in the societal and economic spheres than in the biological and technical spheres. We should see CE as a process or approach to solving our problems rather than a ready to apply solution. In a clever combination with policy, Circular Economy could be an important step forward.

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