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Circular Economy: Paradise Restored?

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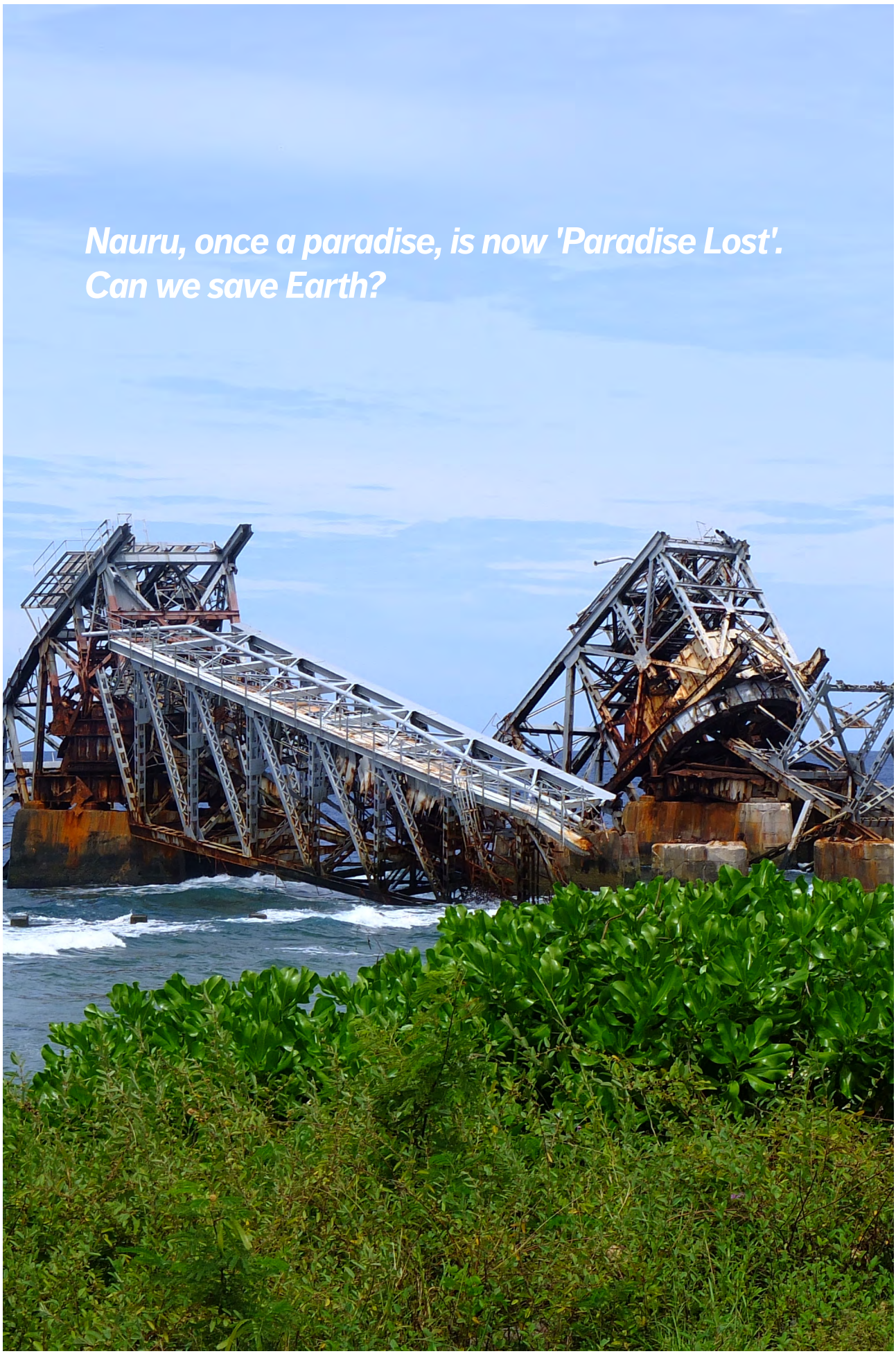

Nauru, once a paradise, is now 'Paradise Lost'.
Can we save Earth?

Paradise Lost

In the 1970s, the tiny Pacific island of Nauru had the highest income per head in the world after Saudi Arabia. The money has come from intensive mining of its ample phosphate reserves, built up over countless years by the accumulation of seabird droppings and used as fertiliser. However, now most of it is gone – as have most of the seabirds that provided it, because the phosphate mining has ruined their habitat. The nation is heavily in debt, and relies on handouts from Australia. Meanwhile, because of the mining, the ecosystem for humans is equally bad: the island's interior – 80% of the land mass – is uninhabitable.

Nauru is a classic example of what's wrong with the "linear economy". Under this system, resources are extracted to provide some function for humanity, used up and then thrown away. Little thought is given to what might happen to local people when their resources are depleted. Little consideration is given, either, to the "negative externalities" of using these resources that will afflict the locals or the world in general. "Negative externalities" is the name given by economists to the negative side effects of production and consumption that don't directly cost the producer or consumer anything, but impose a cost on another group, or on society in general. In Nauru's case, the negative externality was the ruination of most of the land.

Another way of looking at this is to think of different countries, and the world in general, as having "natural capital". This means natural resources in the broadest sense, including a habitable climate and landscape, and resources that can be exploited economically. In seeking economic growth at all costs, Nauru exhausted its natural capital. It had, critics might say, been turned into the world's first disposable country.

We call this model of unsustainable economic exploitation the linear economy because, like a straight line, it never returns to the beginning. Once something is used up, it's used up or depleted forever. The linear economy is sometimes known as the take-make-use-and-waste model. Its opposite is the circular economy.

The Circle of Life and Energy

Throwing away the 'throw-away' model

The term "circular economy" relates to the concept of the **circle of life and energy**, which assumes that nothing comes from nothing and **nothing is ever wasted**. If the human race is to prolong its existence on this planet, it should at least aspire to change its model of existence in the image of nature's own. The circle symbolises the ultimate sustainability of existence, something that may well provide an answer to the so far almost uncontrollable human consumption, which has caused climate change, extreme weather, pollution and pandemics. Politicians, consumers, businesses and investors are increasingly thinking that we need to embrace the idea of the circular economy. This is where the resources used to produce what we consume can be used again, and neither the production nor the consumption need to draw further on raw materials, or take further from the natural environment or, on the other hand, reduce the standards of living.

The opposite of the circular economy is the **linear economy**, the **take-make-use-and-waste** model. The energy-intensive manufacturing and construction sector, for example, still largely follows a linear economy model as it is responsible for 12% of all CO_2 emissions, according to the World Resources Institute, a non-profit organisation: mining the raw materials and making them into finished goods or buildings is energy-intensive. The chemical process of making the cement also emits CO_2, adding up to another 3% of total global emissions. The linear economy problem doesn't end with the production process. Products are then often thrown away after use, with little thought given by companies or consumers to recycling the materials. And although the world is not going to run out of the necessary raw materials any time soon, it may be more expensive, and more environmentally damaging, to extract the materials as easier sources are used up.

Changing to a more circular economy requires a change in the way the world does business. This means moving away from the pure free market approach espoused by economists such as Milton Friedman, who regarded shareholder return as the overriding responsibility of corporate management, to an approach where companies must consider wider society. Companies are already responding efficiently to the new priority placed by governments and investors on maintaining a system that's self-sustaining and leaves no lasting damage. Some people might indeed call this "sustainability", but we prefer the term "circular economy" because it describes the process needed to keep the world in a healthy equilibrium.

Investors might balk at the idea of having to consider yet another issue, when they're already performing the mental gymnastics of juggling huge short-term issues like Covid-19 and longer-term sustainability issues encapsulated under the ESG umbrella: assessing companies on their good or bad Environmental, Social and Governance practices and credentials.

"The link between deforestation and the spread of zoonotic diseases has been proven."

However, the outbreak of Covid-19 can be considered through the circular/linear economy lens. It probably originated in a market in the Chinese city of Wuhan selling a huge variety of live animals, many of them wild. The exploitation of wild animals by humans increases the chance of "zoonotic spillover" – where a virus found in an animal spreads to humans. This is because captured animals in a state of stress, in a run-down state of health, are more likely to develop a virus-based illness and some of these illnesses can spread to humans. Moreover, the link between deforestation and the spread of zoonotic diseases has also been proven. With the loss of their natural habitat, populations of animals get struck by death and illness and those that remain often inevitably move closer to where humans live. This increases the risk of new infections crossing over into human population.

Covid-19 can also be seen as a negative externality. It's a reminder that if we do not take systemic risks seriously, the socio-economic consequences can be devastating. Covid-19 also shows us just how many nasty negative externalities lurk beneath the surface. "Infectious diseases" didn't make it into the 2020 World Economic Forum Risk Report's list of the ten risks most likely to happen – but it was a top ten risk in terms of impact[1].

As for investors' interest in ESG and sustainability, we don't see an interest in the circular economy as diverting attention from this.

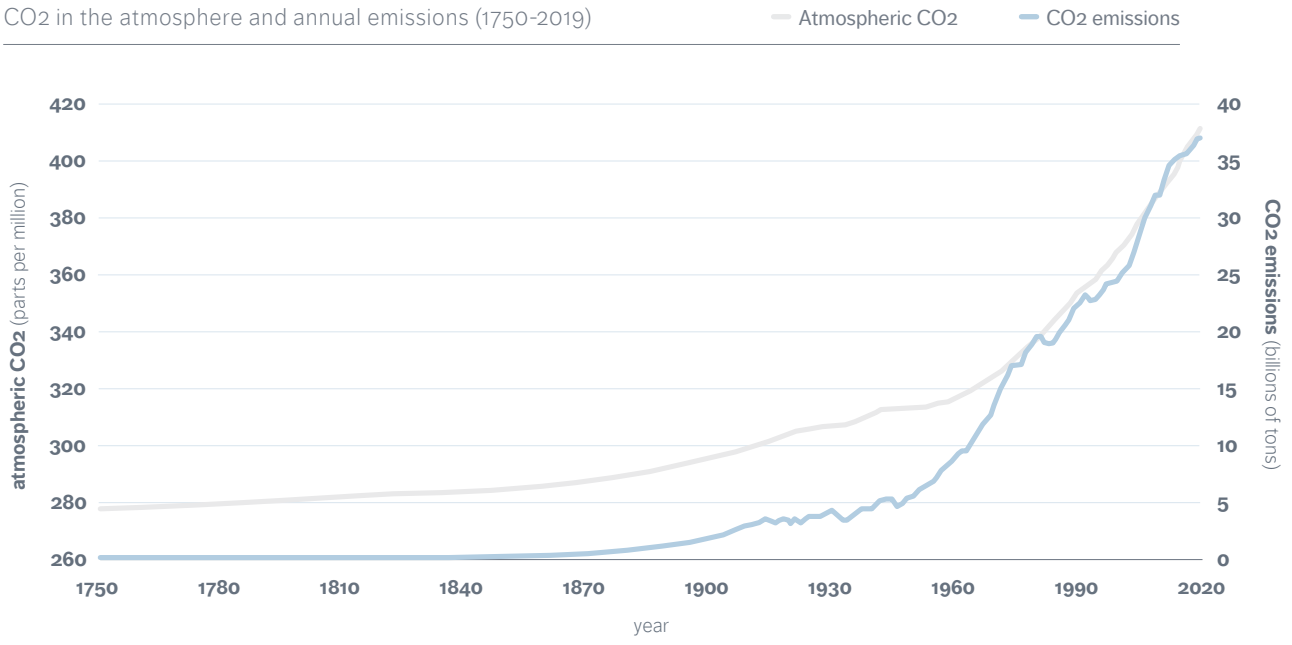
Aware of the urgency of looking at the circular economy and the behavioural shift it requires from all stakeholders, in this paper we discuss how the circular economy works, the reasons for it, how businesses and consumers are responding to the need for it, and what the obstacles are. We also consider how both institutional and individual investors can profit from and encourage this trend.

The linear economy: a line leading straight to disaster

Let's first look at just how much damage the linear economy is causing. The highest-profile casualty of the linear economy is the atmosphere. The greater concentration of carbon dioxide, nitrous oxide, methane and other greenhouse gases is warming the planet. This concentration is increasing because of economic activities that have intensified over the past half-century. Energy consumption for both domestic and industrial needs accounts for 73% of greenhouse gas emissions caused by humans, according to the World Resources Institute, because of the fossil fuel combustion. Farming and industrial processes generate most of the rest. Because of these greenhouse gas emissions, the world is likely to be about 3°C warmer than pre-industrial levels by the end of the century, even if countries make a serious effort to keep to current commitments, and if the energy industry continues its shift towards renewables. That's much higher than the 1.5°C threshold regarded by many scientists as marking the line above which climate change starts to become much more catastrophic.

Figure 1:

CO2 in the atmosphere and annual emissions (1750-2019)

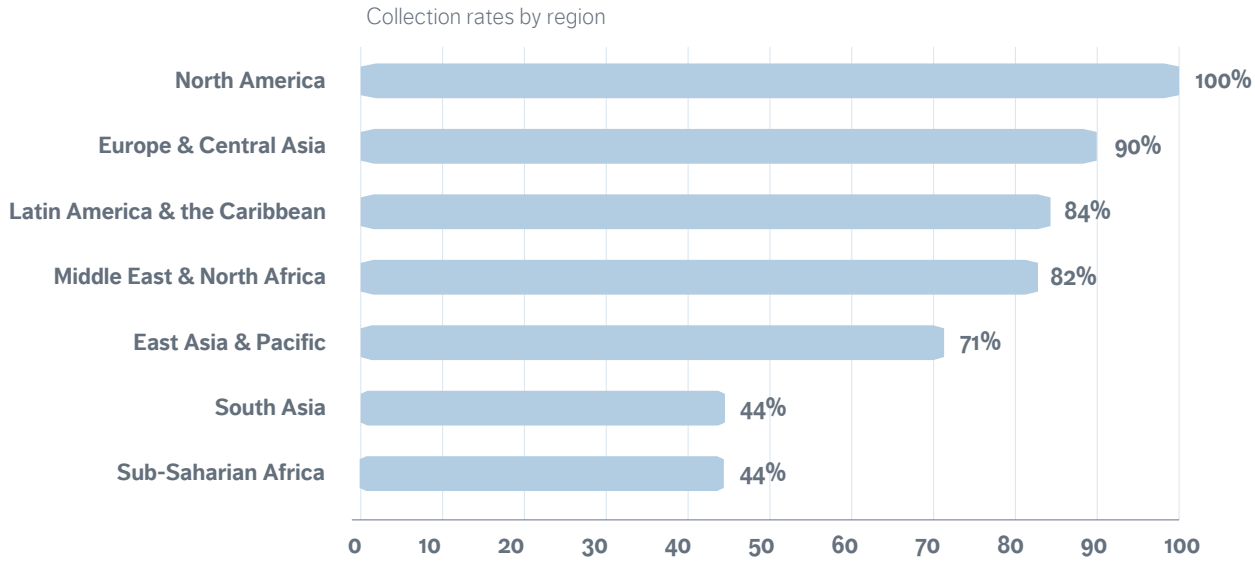


Source: NOAA Climate.gov - Data: NOAA, ETHZ, Our World in Data

A further pinch point of the linear economy is water scarcity. Demand for fresh water is rising because of growing populations, increased demand for a range of products and the spread of irrigation in agriculture. This is a problem because climate change is likely to suppress supply. The World Bank has warned that water scarcity could cost some regions up to 6% of their GDP, spur migration, and spark conflict. In South Africa's Cape Town, city leaders even had to warn in 2018 that they were two months away from "Day Zero", where the taps would be turned off and citizens would have to queue at standpipes guarded by soldiers. In the event, the city authorities have since managed to implement significant water restrictions, reducing the overall daily water usage by more than half. In Australia, mining companies are running out of the water they need in huge volumes to do their work. Some are responding by turning themselves into miners of water as well as gold, coal and copper. This underlines the economic logic of moving to a circular model.

On present trends, many of these linear economy problems will be aggravated as they are intertwined and reinforce each other. The World Bank estimates that without urgent action, global annual waste generation will surge by 70% over the next 30 years – and more than triple in sub-Saharan Africa.

Figure 2:
Waste collection rates

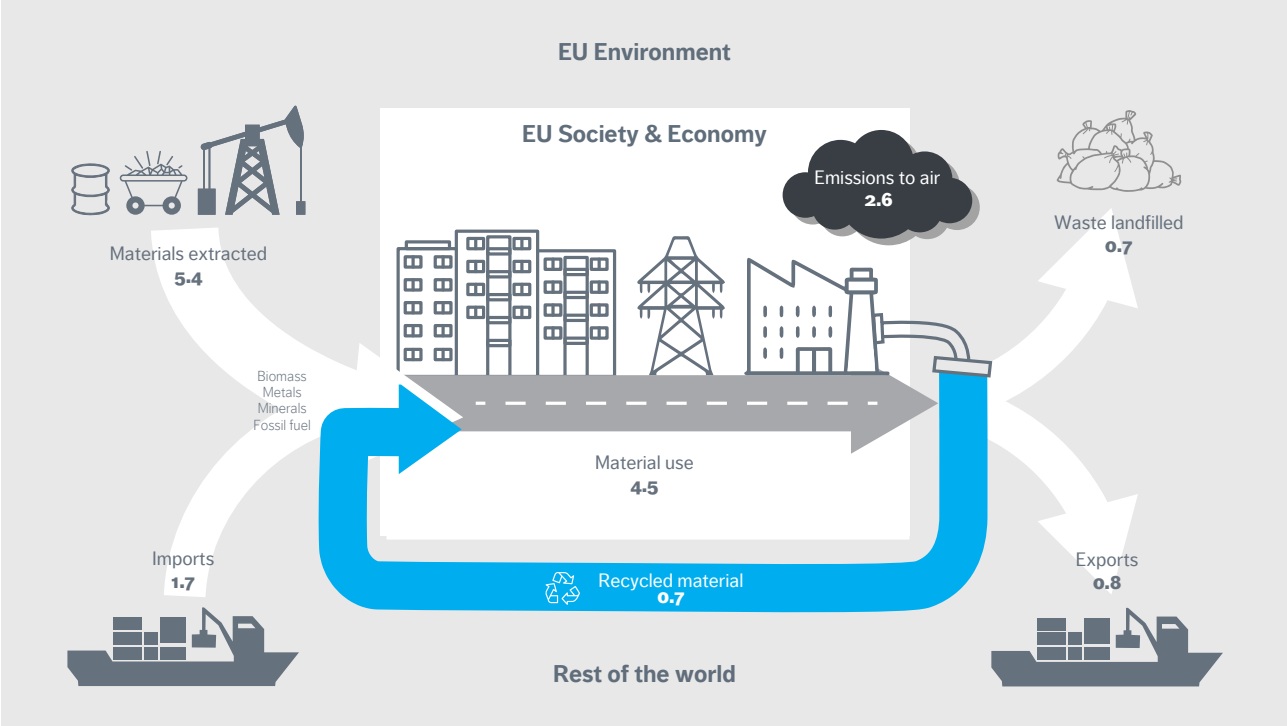


Source: What a Waste 2.0 : A global Snapshot on Solid Waste Management to 2050

"Plastics are especially problematic", warns the World Bank. Marine wildlife mistake plastic waste for prey, and die of starvation as their stomachs are filled with plastic debris. This plastic may end up in our stomachs, with plastic an extra unwanted ingredient in the fish soup we have for lunch. Plastic production is responsible for another negative externality: it requires fossil fuel combustion. Even if plastic doesn't escape into the sea, it still creates a problem, by contributing to the world's landfill problem. The degradation of wastes in the landfill generates leachate and various greenhouse and other gases, which threaten human health and the environment.

The circular economy is a solution to all this, but we're not doing very well so far, as workers and consumers, at bending the line into a circle. Even the economy of the European Union, which is probably at the forefront of all major economies on this, is only 12% circular according to the European Commission. The rest of the world is doing worse. Circle Economy, A non-profit organisation, estimates that only 8.6% of all the minerals, fossil fuels, metals and biomass that enter the world economy each year are "cycled back". Alarmingly, Circle Economy even found that the global economy was becoming less circular: back in 2018 the corresponding number was 9.1%[2]. These figures don't take into account consumption that's reduced or avoided, but the consumption of most raw materials is still rising.

Figure 3:
Material flows in EU, 2017, billion tonnes per year (Gt/year)



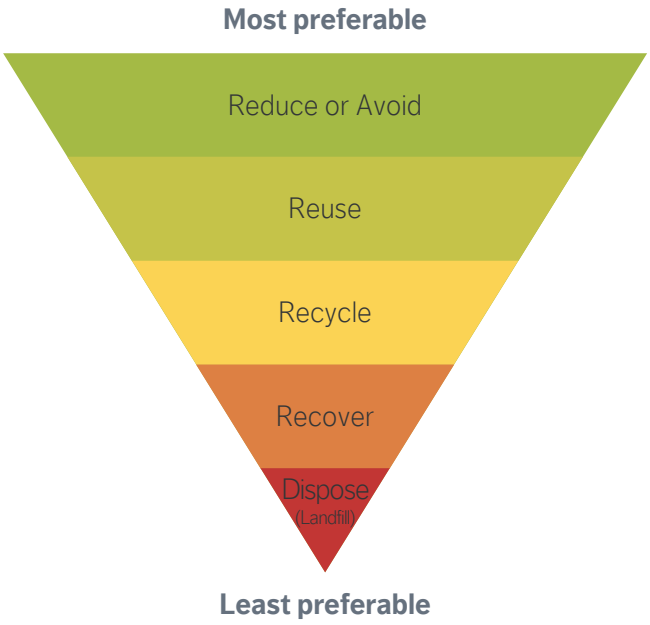
Source: Eurostat

An escape ladder to a sounder future

There is room for hope, however. Our understanding of what needs to be done, and how to do it, is growing more sophisticated. Ad Lansink is far from a household name. You won't find a Wikipedia entry on him in English, though you will in Dutch. This is curious because the Lansink Ladder, devised by the biochemist and Dutch MP in 1979, is an important breakthrough in our understanding of how to create a circular economy.

Lansink argued that the best way forward was to construct a hierarchy of options in the production of goods and services. The best option, at the top of the ladder, is to *Reduce* the use of physical resources or even *Avoid* using them altogether. The next option is Reuse, followed by Recycle and then Recover. The least preferable option, among those in a well-regulated economy, is Disposal in landfill (though unregulated dumping would be even worse). From now on we'll capitalise these terms, to make it easier to see how the circular economy works in different contexts, and to show how it requires a fundamental shift in our behaviour and the way we interact with our environment.

Figure 4:
Lansink's Ladder



Let's apply the Lansink Ladder to milk, taken from cows grazing in meadows. We need to take into account both the milk itself and the carton packaging (or a plastic bottle). We have to simplify to a degree, but we've retained a flavour of the complexity and difficult choices that must be made – embracing the circular economy is rarely straightforward. Milk has quite a big carbon footprint: cows use land that could instead be forested and used to soak up carbon, and cows belch methane, a potent greenhouse gas. Agriculture accounts directly for 12% of emissions, but the destruction of rainforest, largely for farming, also causes global warming in two ways. The burning creates carbon dioxide, and once the forest has disappeared, it can no longer absorb carbon dioxide. Moreover, the milk container is usually made of plastic these days, which involves fossil fuel combustion. Using Lansink's ladder, we can analyse what you and I can do:

- **Reduce or Avoid**: Consider oat milk as an alternative, or soy milk if you're drinking milk for protein. Although Amazon rainforest is being destroyed to make way for soy plantations, most of this is being used to feed cattle, which need enormous amounts of it. If we all drank soy milk rather than letting the cows eat it, and then eating the cows or drinking their milk, there would be no need to deforest the Amazon. Buy one big carton rather than two small ones, because this means less plastic per litre. However, if you do purchase a larger container, make sure you drink it all.

- **Reuse**: Find creative ways of giving cartons a second life. Watering can or storage container, for example?

- **Recycle**: Put the cartons in the correct bin, well-rinsed, so that they can be processed and turned into something else. Manufacturers can use Recycled plastic for new milk cartons. Farmers can use the cow manure to boost soil fertility.

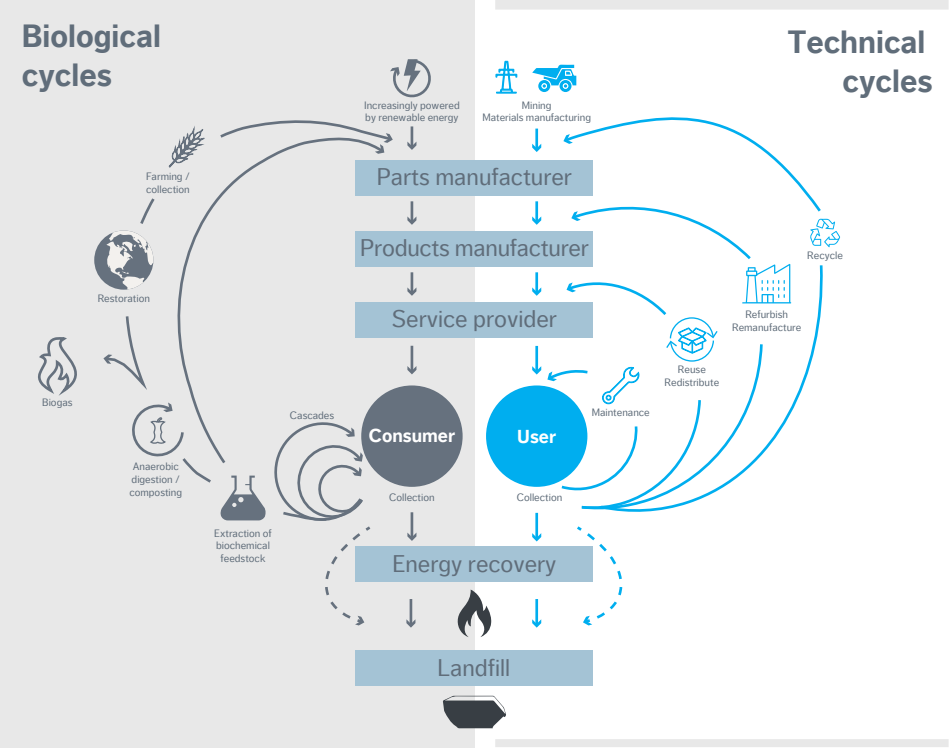
- **Recover**: Municipalities can burn the plastic in the incinerator, producing heat and steam that generates electricity.

- **Dispose**: If recycling facilities don't exist, municipalities should put it in a suitable landfill site.

It makes sense to talk about a Lansink Ladder, rather than a menu of options, all of them equally valid, as we have in Word documents on our PCs. Recovery is not particularly effective, so Recover is worse than Recycle: the energy Recovered from burning plastic is much less than the energy used to make it in the first place. However, the quality of plastic made from Recycling is worse than virgin plastic, and Recycling plastic is notoriously fiddly, because of the many different kinds. For this reason, much of the plastic in our Recycling bins may end up incinerated, in landfill, or in the worst case illegally dumped. As for Reuse, there's a limit to the number of watering cans made out of milk cartons we could possibly use. Reducing or Avoiding milk consumption circumvents all these problems.

Another way to understand the circular economy is shown in the diagram below, from the Ellen MacArthur Foundation, a charity dedicated to spreading the circular economy set up by the record-breaking yachtswoman. It displays what looks like a conveyor belt in the centre, with energy, mining and manufacturing at the top and landfill at the bottom. It also shows how we can keep resources running on the conveyor belt, rather than consigning them to landfill, through the actions of companies and consumers, including Reusing and Recycling.

Figure 5:
Outline of a Circular Economy



Source: Ellen MacArthur Fondation, SUN, and McKinsey Center for Business and Environment

Dramatis Personae

Consumers are beginning to care

The average consumer certainly hasn't heard of the Lansink ladder, but in many countries they're becoming increasingly keen on Reducing, Reusing and Recycling – and on buying from the companies that do these things.

Consumers need to move away from the rationale that the best product is whatever meets their expectations of quality at the cheapest price. In other words, they need to have long-term point of view, and take into account the negative externalities of a product. Or to look at it from an alternative perspective, they need to regard the product's imprint on the wider world as an important aspect of its quality. There are indications that consumers are prepared to fund the removal of these negative externalities, by paying more for brands with strong commitments to the circular economy. Pukka, the British tea business now owned by Unilever, is an example. It has worked hard to Reduce its carbon footprint, to the point where 49% of the carbon impact of a Pukka cuppa comes from consumers boiling their kettles.

Consumers are also vital to changing the line into a circle because consumers are citizens, and citizens shape what governments do – particularly in democracies but even to a degree in all but the harshest autocracies.

"Only 8.6% of all the minerals, fossil fuels, metals and biomass that enter the world economy are 'cycled back'."

Governments draw swords on the linear economy

National governments and supranational bodies are already encouraging the circular economy in many ways, but they need to step up their game.

The most famous initiative is the attempt at international action to reduce global warming. The Paris Agreement was signed by almost every country on this planet, pledging to rein in their greenhouse gas emissions, with the aim of holding the increase in the global average temperature to well below 2°C above pre-industrial levels. The move towards a circular economy is also encouraged by many of the United Nations' 17 Sustainable Development Goals for 2030. These were adopted by all member states in 2015, with the aim of ending poverty, protecting the planet and spreading peace and prosperity. They include, for example, Goal 7 – "affordable and clean energy" – and Goal 12 – "ensure sustainable production and consumption patterns".

In December 2015, the European Commission adopted a Circular Economy Action Plan. This wide-ranging policy set new standards for member states – for example, under revised waste legislation, 70% of all packaging waste should be Recycled in each member state by 2030. A new Circular Economy Action Plan, published in March 2020, includes an intention to introduce mandatory requirements for what packaging is allowed in the EU, in a bid to Reduce overpackaging. The Plan also discusses a European Commission Strategy for a Sustainably Built Environment, promoting circularity principles for buildings.

"The citizens of developed countries have been too ready to think they are doing their duty by putting their rubbish in Recycling bins, with little thought of the complexities."

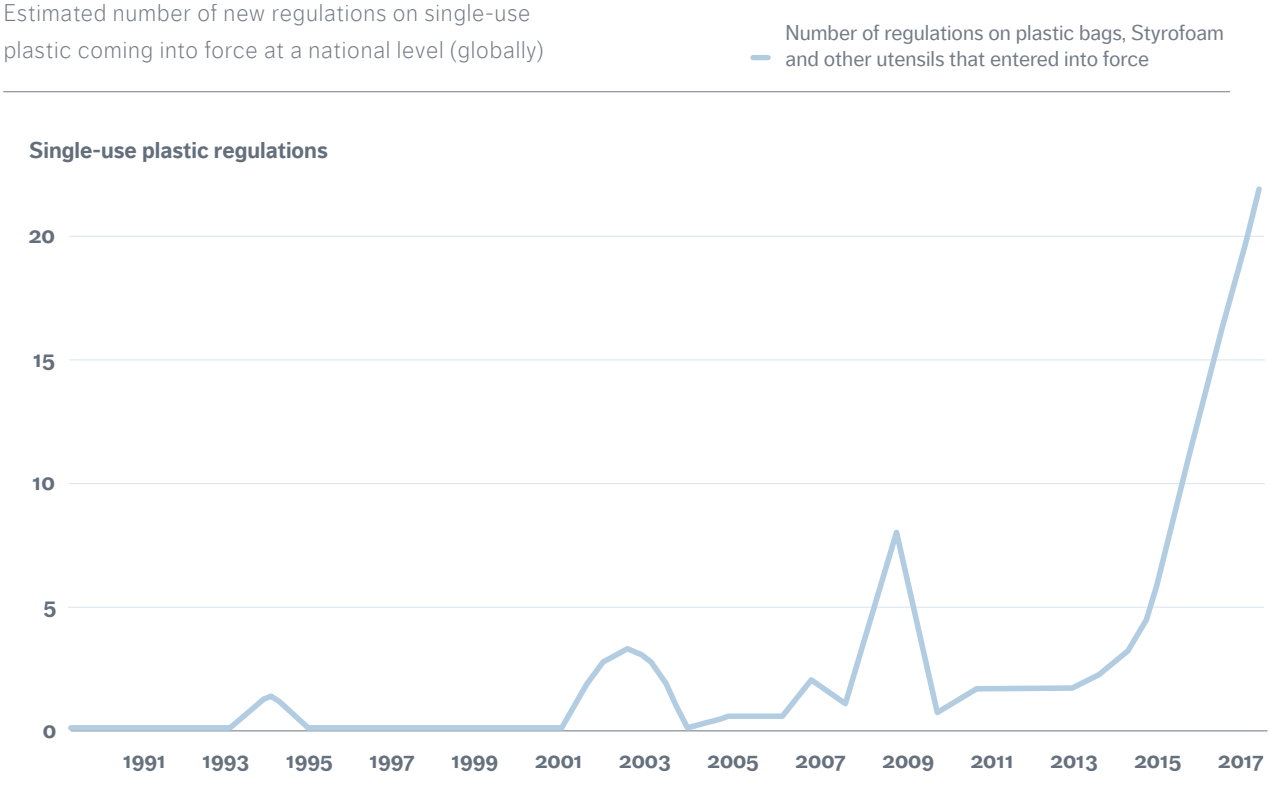
Many of these supranational policies involve progressive changes, but China's National Sword policy was more dramatic. In 2018, China, which was previously the centre of the global Recycling trade, shut its doors to imports of all but the purest plastic, as large amounts of the waste were "dirty" or "hazardous" and thus a threat to the environment. The Chinese state had a valid point: although this trade provided employment to local people, the citizens of developed countries have been too ready to think they are doing their duty as global citizens by putting their rubbish in Recycling bins, with little thought of the complexities for society of dealing with this waste after it's taken away by rubbish trucks. The same can be said for CO_2 emissions: experts worry about "carbon leakage", where businesses in highly regulated home countries locate their carbon-intensive activities in countries with less strict environmental regulation, but consumers often give little thought to this[3]. For example, many manufacturers headquartered in the UK or France, countries ranked in the top ten in Yale and Columbia Universities' Environmental Performance Index, site factories in China, ranked 120th. Many developed market clothing companies use factories in Bangladesh, ranked 162nd out of 180 countries[4]. Although other countries took up much of the slack in plastic Recycling, the *Financial Times* estimates that waste exports from the Group of Seven large advanced economies (G7) fell 20%.

The National Sword policy is not unalloyed good news for the circular economy. Imports of US plastic waste by other countries that cannot even deal with their own waste (including Bangladesh) have surged. Observers fear that much of this will simply be dumped. Having said this, the discovery that middle-income countries such as China are no longer willing to take rich-country detritus increases the pressure to Reduce the quantity in the first place.

China's decision has already had a domino effect, with India, Thailand, Vietnam and Taiwan imposing or planning to impose partial or total bans on the import of plastic scrap. That sits alongside tighter domestic regulation of single-use plastic in much of the world. For example, the EU's Single-Use Plastics Directive will ban products for which alternatives exist on the market, such as single-use plastic cutlery, by 2021. This will have a knock-on effect, reverberating along the full consumer and production value chain.

Governments also shape the views of their citizens, as well as the other way round. Many governments are making it easier for consumers to see the consequences of their purchasing actions. For example, EU lighting products, and various consumer electronics such as washing machines and televisions, must by law carry energy efficiency ratings, which inform the consumer.

Figure 6:
Estimated number of new regulations on single-use plastic coming into force at a national level (globally)



Source: UN Environment, Single-Use Plastics A Roadmap for Sustainability

Companies respond: riding the megatrend

If governments and consumers are setting ethical or social rules and pursuing higher environmental and health standards, it's much easier for companies to play their part in making the global economy more circular. It's extremely tempting, otherwise, to regard any negative externalities in supply chains as "someone else's problem".

There are powerful negative incentives for companies to become circular, including reputation and regulatory risk. If a company sticks to a linear economy model while governments' and citizens' expectations for circular economy practices are being ratcheted up, it may be fined by the regulator and boycotted by the consumer.

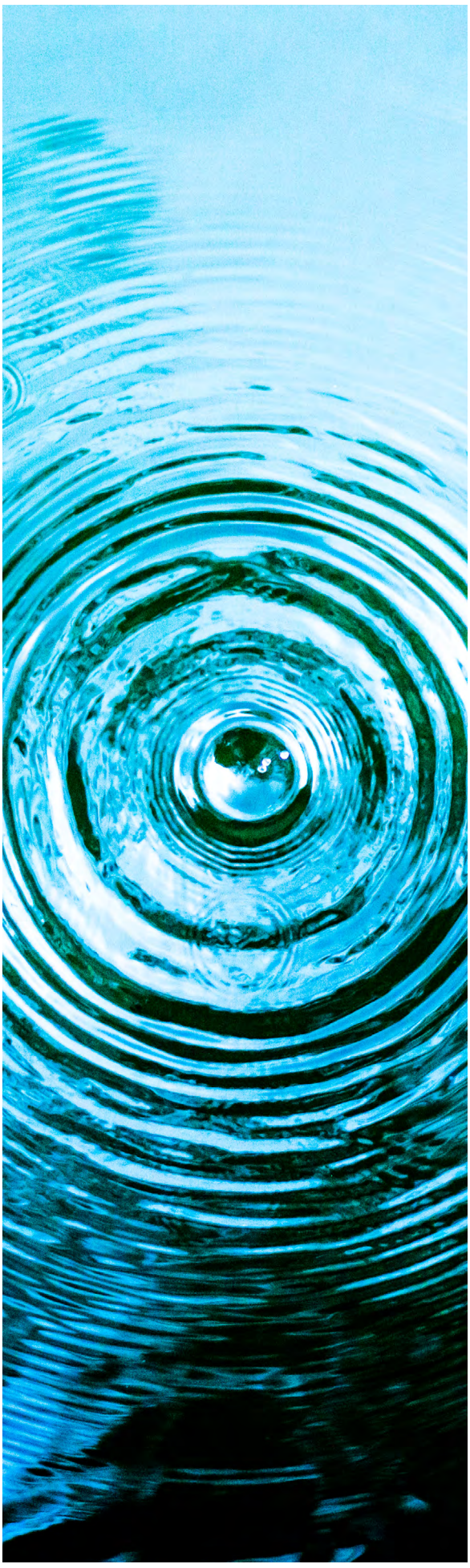
However, the positive impetus of first-mover advantage – the market opportunity in embracing the circular economy before competitors – is just as powerful. Reform begins at home: companies need to start with a recognition that if the world is overconsuming, they probably are too. They then need to take into account all negative externalities throughout the value chain, and implement best practices from other companies in their sector (and come up with one or two of their own) to move towards a circular model. This is partly about gaining customers, and hence boosting income, by enhancing reputation. However, it's also more cost-efficient for companies in the long run, after they've made the initial up-front investment in changing processes. For example, as we discuss in "Closing the loop" later in this paper, some materials are much cheaper to Recycle than to mine from scratch. If companies can use circular economy practices both to increase topline growth and to cut costs, they can generate more cashflow and earn fatter margins. These can be sustained and used to increase profits if they have a strong market position, or slimmed down and passed on to consumers in highly competitive industries. Alternatively, the cash can be ploughed back into capital investment that boosts circular practices, and hence competitive advantage.

"The impetus of first-mover advantage is powerful."

Moreover, the surge in interest in the circular economy issues of climate change, efficiency in energy and resource use, and waste management, has given birth to entire new industries that have breathed new life into existing companies and gave birth to new ones. This encompasses a diverse range of businesses trying to help other businesses, as well as governments and consumers, join the circular economy. To return to the example of organic milk, companies such as the US' Australis Aquaculture are trying to commercialise the production of *Asparagopsis*. It's a red seaweed that, if eaten by cattle, could Reduce the methane in their belches by up to 95%.

Looking at the bigger picture, the move to the circular economy is a structural megatrend, as unstoppable as wave in high winds or a charging bull. Like Hawaiian surfers or Ancient Minoan bull-leapers, it's best for businesses to ride this megatrend rather than trying to resist it. As citizens, we should find cause for optimism as businesses do this. The free market is a fertile breeding ground for inventiveness, as businesses vie with each other to find ingenious solutions, if they perceive a good enough commercial, business or financial opportunity. It's not hard to find such openings: if the global economy is only 8.6% circular and 91.4% linear, the opportunity to improve is much greater than if it were already 91.4% circular and 8.6% linear.

Let's look at what companies can do in more detail.



The Game-changers

Raw materials: getting to the meat of the problem

The world is short of farmland, if it also wants to keep rainforests. However, for many natural resources the main circular economy problem is not exhaustion but damage: the pollution or depletion of the environment caused by extracting and using these resources.

The best way of easing such negative externalities is the top rung of the Lansink Ladder: Reduce or Avoid.

An important Avoidance strategy is renewable energy. Increased renewables use should move us progressively further away from using oil and gas as power. This includes direct use – in vehicles and gas-fired boilers, for example – and indirect use, through electricity generated by burning oil and gas.

The increase in the use of alternative energy and better technology has brought the costs of it down. For example, the cost of silicone photovoltaic solar panels declined by 99.5% between 1977 and 2014[5]. The renewables industry continues to dream up innovations that will increase cost efficiency and capacity. Portugal's Windplus consortium has developed a semisubmersible floating wind farm that can be installed in deep waters that were previously inaccessible, allowing abundant wind resources to be harnessed. The consortium members are EDP Renewables, Engie, Repsol and Principle Power. Such pioneering examples of renewables technology are expensive for first movers to developed, and those that merely follow in their wake will be able to deploy such technologies at lower cost. However, the companies that pioneer may well retain an advantage in know-how even as adoption becomes more widespread.

Another important circular economy issue is deforestation. The world's temperate forests have not seen any significant reduction in recent decades, but the amount of "primary", or very old, tropical rainforest, is the crucial consideration. It soaks up the most carbon, and also has perhaps the richest diversity of flora and fauna species of any habitat on the planet. Brazil, Colombia and Peru, three countries subjected to severe deforestation, have the highest number of bird species in the world: almost 2,000 each, out of a global total of about 10,000. Unfortunately, however, the world loses an area of primary tropical rainforest about the size of Belgium every year[6].

"The best was is the top rung of the Lansink Ladder: Reduce or Avoid."

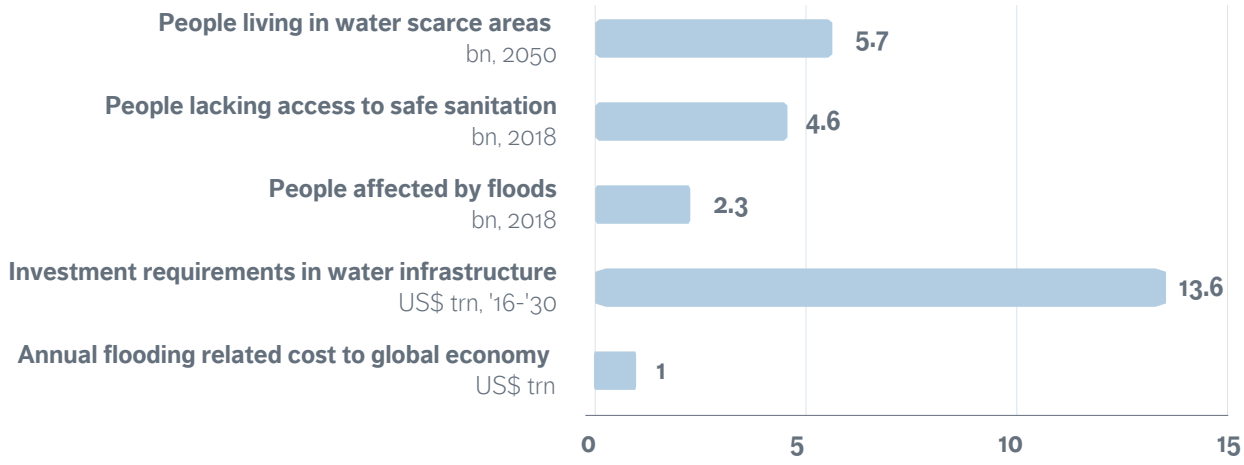
There are many reasons for this linear economy problem. Farmers destroy forest to make way for pastureland for cattle; miners cut swathes through forests, to extract resources; in poorer countries, ordinary people use trees for firewood.

Consumers and businesses can respond by Reducing or Avoiding consumption of products causing this linear economy pressure. Shoppers can buy alternatives to meat, for example. The US company Beyond Meat has developed plant-based meat substitutes that mimic the taste of real meat much better than earlier alternatives, according to aficionados. In a sign of the size of the circular economy opportunity, Beyond Meat's market capitalisation surpassed $10 billion in 2019, enabling early believers in the company to recoup their initial private investments more than 50 times over.

Another solution is carbon offsets. That's where a business or concerned individual tries to offset their carbon footprint by giving money to organisations that protect existing forests and plant new trees. The Zimbabwean company Carbon Green Africa is looking after local forests, and using the money to teach local communities to adopt the circular economy. For example, it has taught people to use cow dung as an alternative fuel to wood – one local hospital even accepts payment for medical bills in it. Microsoft has already declared itself carbon neutral through offsetting, and plans by 2030 to be "carbon negative" – saving or generating more carbon than it uses.

A further pinch point is fresh water, which will become scarcer in many places as global warming continues. A partial solution is for households and businesses to Recycle the water they've already used, known as greywater. Several US breweries are using greywater scrubbed clean by Cambrian Innovation, a company partly funded by Nasa, which has used the technology on the International Space Station.

Figure 7:
Water: the key issues are large and widespread



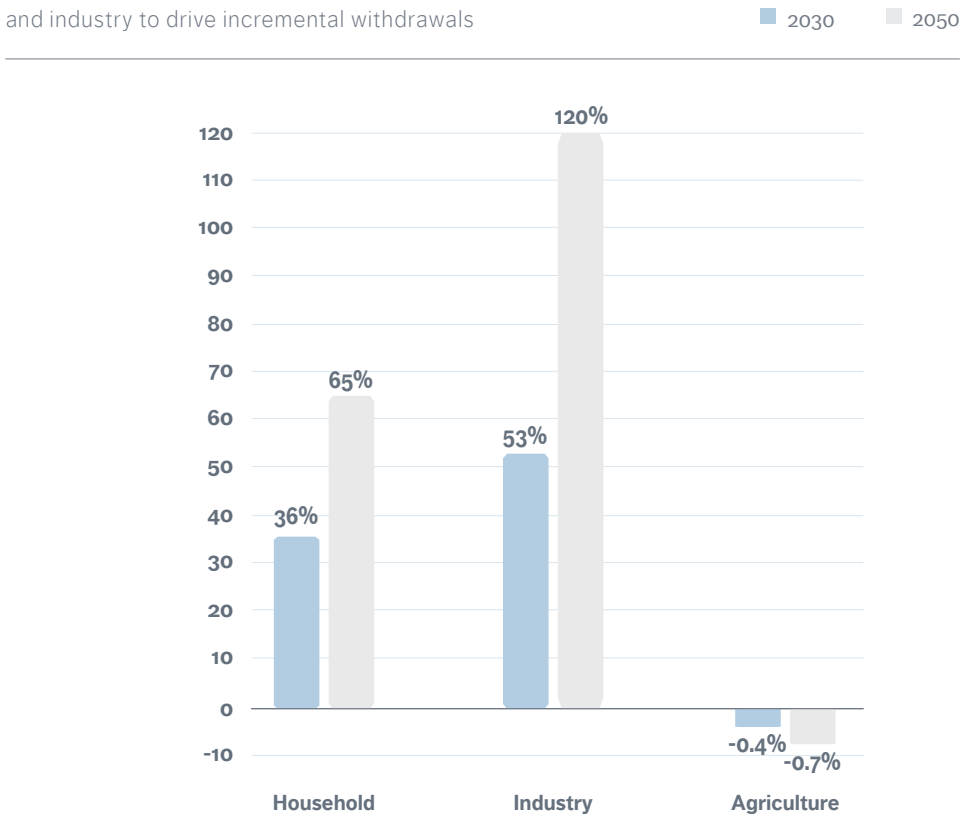
Source: Credit Suisse ESG Research

There are also supply constraints for many of the metals used by modern industry, such as consumer electronics and electric vehicles. Past declarations that the world as a whole would run out of a particular finite natural resource have usually been proved wrong by history. *National Geographic* magazine's 1974 article, "Oil, The Dwindling Treasure", is a good example. However, many resources can become locally depleted, presenting problems for particular companies. Moreover, even if attempts to find new sources succeed, global supply can be constrained for many years, pushing prices higher and decreasing corporate margins until new production comes onstream.

One potential pinch point is in the metal cobalt, used in the batteries of smartphones and electric vehicles. Demand is rising exponentially: Bloomberg New Energy Finance predicted in 2017 that it could multiply forty-seven-fold by 2030. This is a problem, because 70% of global production is in one extremely unstable country, the Democratic Republic of Congo; the resulting global instability of supply makes the price of cobalt extremely volatile at times. Such supply constraints and pricing pressures make it logical for businesses to be sparing in their resource use.

Figure 8:

Projected growth in types of freshwater use: households and industry to drive incremental withdrawals



Source: Credit Suisse ESG Research

Designing products: fighting the fast fashion mentality

The ideal circular economy product is durable, easy to repair or modify (allowing us to Reduce consumption), and easy to Reuse or Recycle.

Durability is a complex subject. It's partly about the physical quality of the product. The proliferation of "fast fashion" brands is a classic linear economy problem: these clothes won't last long because they're cheaply made, but the people who buy them don't care because the price tag is low. Products can also be short-lived because they appeal only for a limited period. Many fast fashion designs are responses to what particular celebrities are wearing, and these clothes are only briefly in vogue. In any case, Instagrammers don't like wearing the same outfit in a second photo. In other words, fast fashion is disposable clothing.

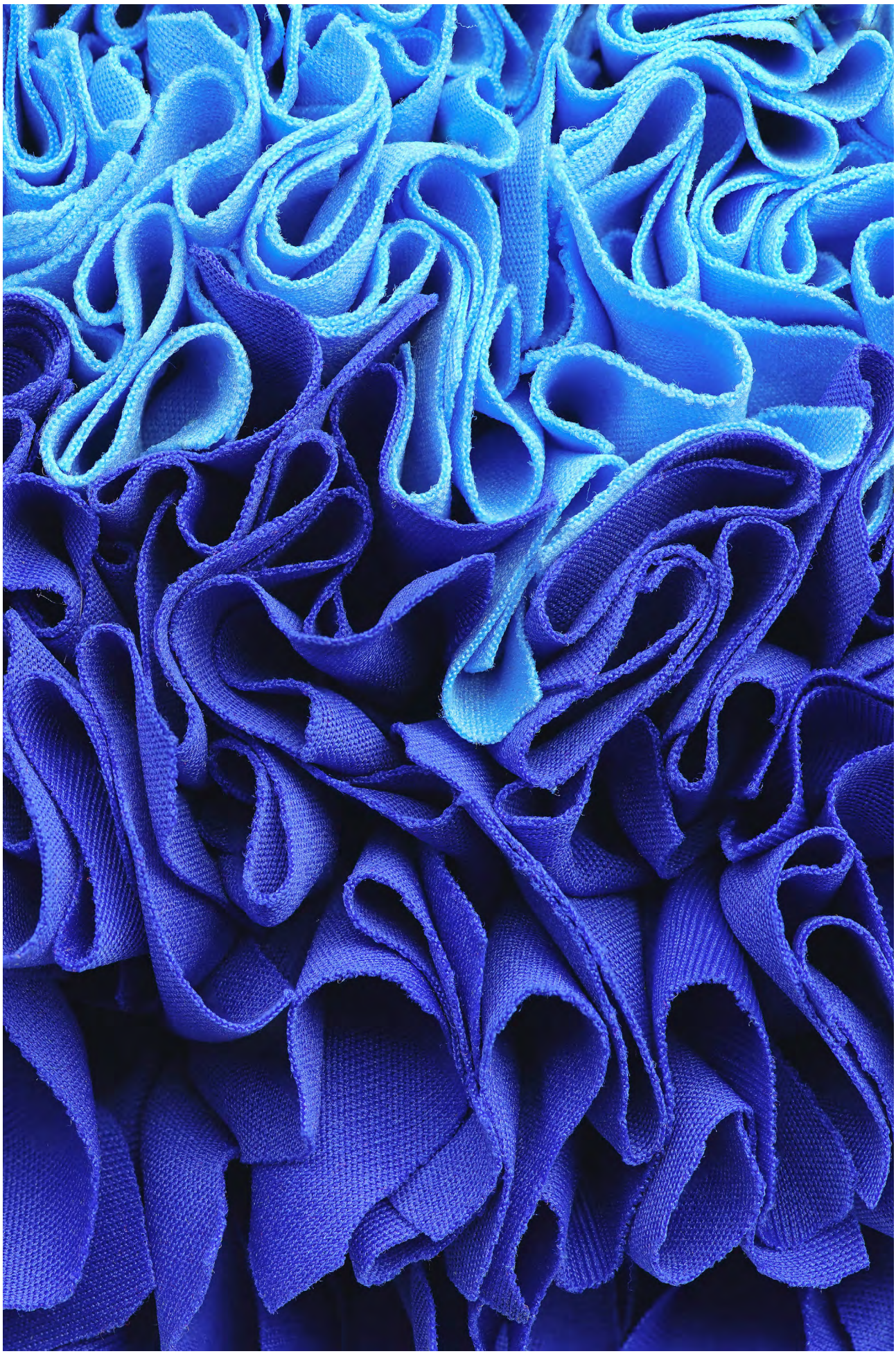
This is no longer sustainable. Companies are actually able to make profit and prolong product life by making items physically stronger in the first place. Some are also experimenting with products that can repair themselves, such as self-healing leather and building materials. Scientists have experimented with incorporating calcium sulfoaluminate into cement-based materials, to close cracks that may appear later[7]. US firm SAS Nanotechnologies has invented self-healing microcapsules in paint that act as an anti-corrosive pigment.

Another approach to extending the life of both products and raw materials is modularity: creating products with a limited number of standardised and easily separated components that can be replaced, or recombined to make new products. The Dutch company Fairphone has created a smartphone designed to last much longer than the typical device, because users can easily replace their own screens, batteries and other parts as they shatter, wear out or become outdated. Buyers are encouraged to return Fairphones or any other old smartphones in the empty box, and receive cashback or a discount.

Britain's Unusual Rigging, which provides gear for theatre productions and public events, checks the tensile strength of components, using MRI scanners, to see if they can be Reused. Using the technology, it recently built a new warehouse out of gear left over from Queen Elizabeth II's 2002 Golden Jubilee. It has also started making devices in modular form, designed for easy disassembly. Because of this, after providing the rigging for the London Western End production of Shrek, Unusual Rigging was able to Reuse 85% of the same gear to stage a production of *Charlie and the Chocolate Factory* in the same theatre, at a 30% discount to the client. This is a good example of where better design reduces costs by using resources more efficiently, including extending their useful lives. This windfall can be used either to boost margins or, if the efficiency savings are passed on to the customer, to compete on price. Other companies in other sectors are likely to follow Unusual Rigging's example.

Disassembly for Reuse or Recycling is easier if products are "monomaterials" – made with a single material – or at least with the smallest number of materials necessary. Germany's Metro, which operates membership-only warehouse clubs, has pledged to use monomaterials in its packaging where possible to improve Recyclability, with the stated aim of "supporting the circular economy approach". This requires heavy R&D spending, but chemicals and engineering companies are responding to this demand. For example, Germany's Siemens, Spanish machine maker Bossar Packaging and US packaging company Scholle IPN have developed a technique for making recyclable monomaterial film. The increasingly clamorous eco-fashion movement is calling for more clothes to be made from pure cotton, pure nylon or other single materials.

When manufacturers have little choice but to create a product made from a number of materials, work can still be done to make it easier to disassemble – for example, by not incorporating adhesives or hazardous waste. This has given birth to a new field, "active disassembly", where the product is designed using materials and processes that break it apart in reaction to external stimuli. Joseph Chiodo, an inventor who runs a company called Active Disassembly Research, has worked with Mitsubishi Heavy Industries, Sony and Nokia on research projects in this field. He has devised, for instance, a screw that will lose its thread when heated.



Making things that last

Such innovations are helpful, but the greatest obstacle in making product design more circular may be the consumer, who tends to value new products – sometimes just for the sake of being new. Responding to this, experts in design and marketing have talked about creating a more circular economy model through "emotional durability": using marketing to make consumers want to use a product for longer, rather than buying a new one. A spectacularly successful case is the long-running ad campaign for the expensive Patek Philippe watch, described by a marketing professor in 2015 article in The Atlantic magazine as the best advertising campaign of all time. The tag line? "'You never actually own a Patek Philippe. You merely look after it for the next generation"[8].

"Emotional durability*: using marketing to make consumers want to use a product for longer."*

Durability – whether physical or emotional – is highly lucrative for the companies that manage to achieve it, because it allows them to extract more profit from their brand. A product that lasts longer, and that's considered worth holding onto for longer, begins to look good value even if the ticket price is higher than for rivals. However, two parties have to play this game: the manufacturer needs to make products better, and the consumer needs to show some self-discipline.

Closing the loop: Reusing, Recycling, Rethinking

In the ideal world, production would work in an endless watertight loop – an enclosed system from which nothing leaks out. In practice, however, this is hard (though not impossible) to do – which is why Reducing or Avoiding in the first place is at the top of the Lansink Ladder. However, most businesses can do a lot more than this to make their production more circular.

To be fair to businesses grappling with this challenge, some materials are more suitable for Recycling than others. Consider metals. The United Nations Environment Programme estimates that only 1% of rare earth elements, which include the neodymium, dysprosium and praseodymium used in electric vehicle magnets, are Recycled. However, 18% of metals have Recycling rates above 50%[9]. There's a clear economic as well as environmental benefit: making virgin aluminium is immensely energy-intensive, but Recycling aluminium consumes 95% less energy than producing it from raw material. That's given society a powerful incentive to Recycle aluminium; hence the spread of reverse vending machines, which allow consumers to reclaim their deposits on beverage cans. In Germany the Recycling rate has reached 99%, proving what is possible[10].

"There's a clear economic as well as environmental benefit."

For many materials there's an immense variation in Recycling rates, with high rates in many rich countries, and low take-up in developing countries with limited or non-existent state rubbish collection. For paper, for example, the rate is 72.4% in Europe but only 36.7% in Africa[11]. The variation is troubling, because making paper involves toxic chemicals that can leak into the waterways that paper mills adjoin. National and local governments need to develop better infrastructure for Recycling and general waste management, for paper and other materials.

They certainly need to for plastic. At the moment 12% is Reused or Recycled according to the strategic management consultancy McKinsey[12]. This is partly because it's difficult to Recycle, since in many cases a number of different types are used to make a single product. It's also because of the sheer cheapness of producing new plastic.

Innovation

On a positive note, however, innovation abounds in Recycling. Carbios, a French cleantech chemistry company, has developed a bacterial enzyme to break down plastic bottles that can then be Recycled into high-quality new bottles. Existing Recycling technologies usually produce plastic only good enough for "downcycling" (Recycling into something less useful) into clothing and carpets. Carbios has partnered with major companies including the US' Pepsi and France's L'Oréal to accelerate development.

"Recycling of natural resources cuts costs and relieves margin pressure for manufacturers"

Some progress is possible even in rare earth elements. A 2018 paper in a journal on sustainable chemistry suggests "significant but currently unrealised potential" to Recycle more rare earth elements from permanent magnets, fluorescent lamps, batteries, and catalysts[13].

Greater Recycling of natural resources will cut costs and relieve margin pressure for manufacturers, and ease bottlenecks that could at worst stop production altogether. Electric vehicle maker Tesla announced in 2019 that it was developing its own battery Recycling process, which it described as "a compelling solution to move energy supply away from the fossil-fuel based practice of take, make and burn, to a more circular model of recycling end-of-life batteries for reuse over and over again". Tesla added: "From an economic perspective, we expect to recognize significant savings over the long term, as the costs associated with large-scale battery material recovery and recycling will be far lower than purchasing and transporting new materials." Other electric car makers are likely to follow its example. Such recycling initiatives will also be helpful from an environmental perspective: In Chile's Salar de Atacama, a major centre of lithium production, 65% of the region's water is consumed by mining.

Only about 1% of clothes are currently Recycled, but Swedish company Re:newcell has invented Circulose, a new material made in its Recycling plant from clothes with a high cotton and viscose content. The biodegradable material looks and feels like conventional cotton.

Even better than Recycling is Reusing, because this means less leakage of valuable resources and expenditure of energy. Nowadays an increasing number of construction companies are trying to Reuse more material. . They're part of a long tradition: for centuries Italians used the stones from derelict Ancient Roman buildings to construct churches and houses. Denmark's Lendager Group, a consultancy working on circular economy solutions for the construction industry, provides building materials such as glass and wood for Reuse. Another encouraging new development in Reuse is remanufacturing, where companies take a discarded product and then work to bring it back to the same quality, or even upgrade it to a par with the latest models. Norway's Norsk Ombruk says it can squeeze a further five years of "peak performance" from remanufactured white goods such as fridges, which are given new warranties. Moreover, the remanufactured machines are half the price of brand-new machines, because it's cheaper to remake than to make from scratch. Sweden's Electrolux, the world's second largest appliance maker, is a Norsk Ombruk partner.

The notion of repairing products rather than throwing them away is increasingly seen even in wealthy countries as a mark not of poverty and desperation but of sustainable and responsible consumerism. As well as small-scale ventures such as repair cafés, where volunteers fix people's products for free, large manufacturers are taking the idea of repair more seriously. For example, US electronics company Apple, one of the chief targets of the grassroots consumer "right to repair" movement, has launched the AppleCare repair program.

However, it's not easy for branded goods companies to sell the unglamorous virtues of repair and remanufacturing: just consider the media mania that accompanies the launch of the latest iPhone. Moreover, many consumers still regard remanufactured products as sub-standard and maybe even dirty, despite the strict hygiene and quality standards involved. They need to change their way of thinking.

"Remanufactured machines are half the price of brand-new machines."

Changing business models, from baby clothes to bicycles

Companies can contribute to the circular economy through scientific innovation, which can be seen as the enabler of circularity. However, innovation in business models themselves may prove just as important or even more important. This is often built around the broad concept of the sharing economy. That's the idea that we can Reduce production through manufacturing better quality, longer-lasting (and more expensive products), and by encouraging use the same product for more (through renting or hiring for instance) – or for longer (through second-hand markets).

If we take cars as an example, the environmental cost of making a car is high as it involves mining the necessary iron and the other natural resources required in its construction, and the cost in energy of the actual manufacture. A circular solution is to Reduce production of cars, but use the cars we have more intensively, by sharing them with each other. RAC, the British automotive services company, estimates that the average car is only in use about 4% of the time, so there's ample opportunity to make car use more intensive. The growth of large taxi service companies such as Uber will accelerate this intensification if consumers end up buying fewer cars. Consumers are also being presented with a greater range of services allowing them to access cars to drive themselves. BMW and Daimler offer a subscription service for borrowing cars, called Share Now – an interesting example of manufacturers turning into service companies. Peer-to-peer car sharing, where people rent out their own cars when they don't need them, is also offered by companies such as Hiyacar.

There's also a hot new trend for rental services for electric scooters – so hot that in 2018 US e-scooter rental company Bird became a "unicorn" company with a value above $1 billion just eight months after it started – the fastest time from start-up to unicorn ever recorded.

Clothing hire is a classic circular solution to the fact that some clothes are worn only rarely or for a limited period. The expansion began about ten years ago with firms such as the US' Rent the Runway hiring out designer dresses. This is a proposition with immediate logic, since most people wear designer dresses only for a small number of special occasions (just as with dinner jackets and kimonos, hireable for decades). Renting professionally cleaned baby clothes, and swapping for the next size up when necessary, circumvents their particular problem: their short useful life for particular families. Companies in this field include Britain's Bundlee.

Sharing more

These days, people can also rent china and tableware for big extended family dinners, bicycles, watches, cameras and much else.

The business model of selling second-hand items sits high up the Lansink ladder, as an opportunity for Reuse. We have long bought second-hand cars and (in most cultures) second-hand houses without questioning the model, but second-hand clothing has recently expanded from the province of thrift stores and charity shops, into big business. An example is France's Vestiaire Collective, which concentrates on designer clothes and accessories.

Through skilful marketing, companies can even make a virtue of the fact that clothing is second-hand. Outdoor gear company Patagonia has made such garments cool, by including stories from customers and employees involving second-hand Patagonia gear on its Worn Again website. Your worn fleece becomes "better than new", according to its marketing campaign. Patagonia's reputation as a socially responsible company has helped cement its status as a premium brand, able to charge more than competitors.

For companies offering the first sharing economy product in their sector, the initial marketing costs will initially be high because of the sheer novelty of the offering. Consider the contrast between hiring out baby clothes and selling supermarket products, for example. You don't need to persuade someone that it's a good idea to eat food, but you do need to persuade them that they don't need to buy baby clothes. In some cases, making these services more popular will require a marked cultural shift among consumers: for example, weaning couples off the excitement of putting large sets of expensive and rarely used chinaware on their wedding lists at department stores. However, their reward for these high marketing costs is the high recognition factor, as the first brand in their field of which consumers are aware. Other businesses may well follow their example and launch sharing services in the same sector, but in terms of brand recognition they may never quite catch up.

"In some cases, making these services more popular will require a marked cultural shift among consumers."

Obstacles to the circular economy: playing fields and graveyards

"Attempts to boost the circular economy often involve extra costs."

We've set out above the many dimensions in which companies and industries need to battle to make themselves more circular. However, we don't want to suggest this will be child's play. If it were so, the global economy would already be more than 8.6% circular. We should remember this puny number, even if there are many individual examples of companies working hard to make our global economy circular.

One problem is that attempts to boost the circular economy often involve extra costs – particularly in the short term. They may also involve trade-offs between different resources: to use less of one thing you have to use more of another. Consider building materials. Reusing glass windows currently requires more wood for the frames, although that may change. Reusing wood increases labour costs: the beams are shorter, so laying beams down is more time-consuming. Solar panels eventually more than pay back their initial cost, but this takes several years at a minimum.

But "circular" does not mean "unprofitable"

The extra cost is no argument against the circular economy, and any extra labour involved will be good for the economy as a whole as countries try to recover from the coronavirus downturn by boosting employment. However, governments must acknowledge that the process needs managing. Tough regulation setting out circular economy standards makes this a lot easier, by creating a level playing field – all businesses must incur the costs of becoming circular. That would address a common source of cynicism about circular solutions: that unless the market itself is new, they're often proffered by small businesses, which lack the scale to make much difference to the world's overconsumption as a whole. Creating high standards for a circular economy would turn these small businesses from niche providers crying alone in the wilderness to pioneers. Moreover, large multinationals will be prepared to institute circular practices at scale if they know that rivals will have to bear roughly the same initial cost at roughly the same time.

Another problem is the law of unintended consequences. Every photo of a bicycle graveyard in China is a shocking sight. Dozens of bike share companies competed with each other by offering more bikes, and therefore more ready availability, than their rivals. This wasteful practice was compounded by the age-old economic problem of "the tragedy of the commons", where individual users behave contrary to the common good of all users by depleting or spoiling the shared resource. In this case, users left bikes in places where they clogged up crowded streets and pathways, and took little care about the condition they left them *in*. As a result, local authorities impounded thousands of bikes, and stacked them in huge piles. The end result was the manufacture of far more bikes, at a cost of far more steel, than if bike sharing had never existed.

Lack of common approach

A further issue is the complex mechanisms of international relations. For example, the European Commission wants to compel other countries to meet its climate standards or have taxes added to their products at the EU's borders. That creates a potential conflict between its environmental agenda and its support for free trade, and could prompt tit-for-tat sanctions from trading partners. Redesigning supply chains will also be hard, because of the paucity of information on what contractors in a distant part of the supply chain may be doing. Having said this, blockchain will make it easier to document what has happened to products on the supply chain journey.

Covid-19 has at least temporarily complicated some business models. For example, some people will be reluctant to share various products for a long time even after lockdowns are over; some may balk at this permanently. The response to Covid-19 has also taken up management time that might otherwise have been devoted to switching a business to a more circular model. On the other hand, it has probably permanently accelerated the move away from the linear economy in certain areas, such as business flights. It will also prompt some businesses to shorten their supply chains permanently. Abbreviated supply chains are a boon to the circular economy. They reduce the negative externalities of transportation, which accounts for 16% of human-made greenhouse gas emissions according to the World Resources Institute. In some cases, they will diminish carbon leakage: for example, if a French consumer goods company decides to relocate production from China to somewhere closer at hand, such as Poland, the product will be made according to strict EU environmental standards.

"Another problem is the law of unintended consequences."

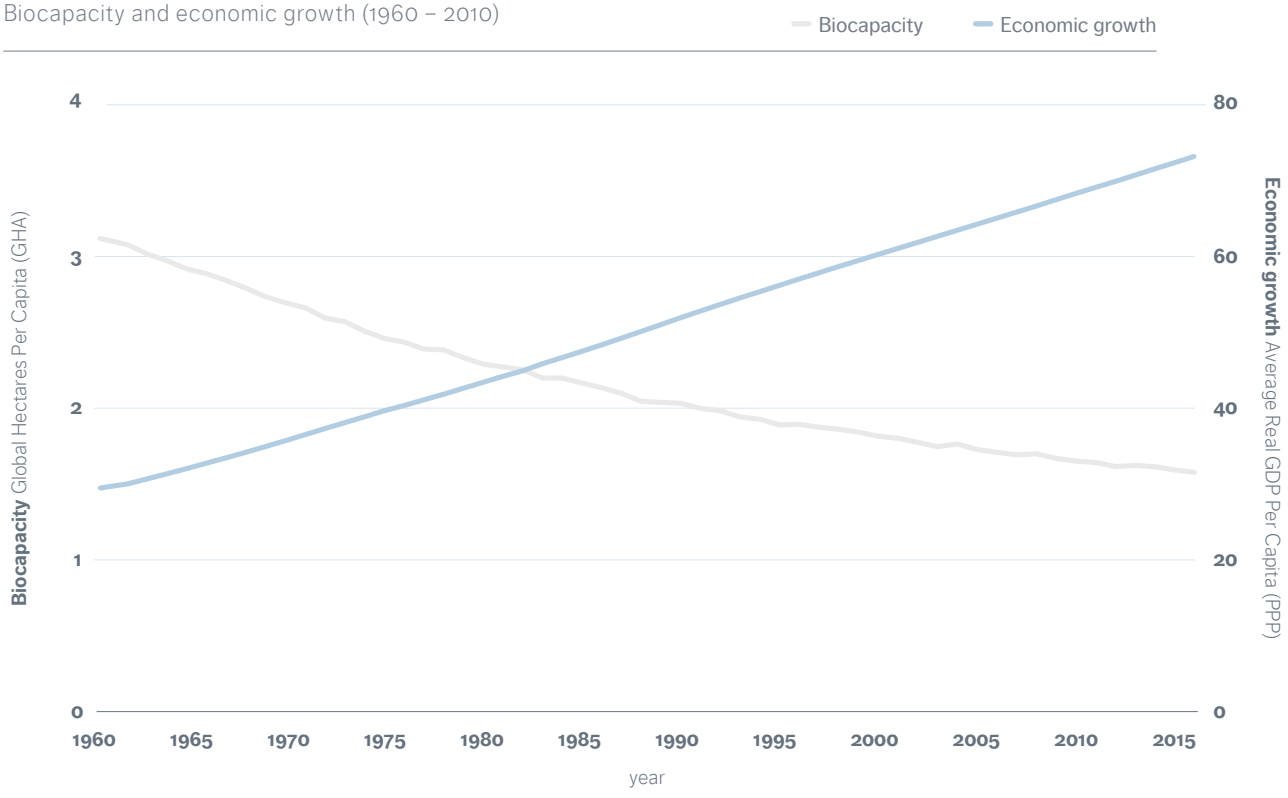
A final problem is the tension between the circular economy and economic growth. The 1970s energy crisis taught us that we could greatly dilute the energy intensity of economic output, or GDP. We have the added advantage these days that even the energy itself may not necessarily pollute, because of the flourishing of renewables.

However, the doubling of Earth's population since the 1970s means that, in our efforts to stop reducing the world's natural capital, we're running to stand still. We need more GDP because there are more people, and if we allow GDP to stay constant while the global population grows, we risk poverty, suffering and a political reaction against any policies constraining economic growth. On the other hand, if we rely on a linear economy to maximise GDP, the damage to the planet will plunge billions back into poverty anyway. The best way of resolving this dilemma is to make the economy as circular we can, and to make the circular economy as efficient and productive as we can. This way economic growth can be decoupled from the biocapacity degeneration.

Figure 9:

Economic growth financed by spending our natural wealth

Biocapacity and economic growth (1960 – 2010)



Sources: National Footprint Accounts (2018), Madison Project Database (2018)

Governments will have an important role to play in this. They can steer companies and people away from the linear economy, through taxation, and towards the circular economy, through tax breaks and subsidies. Skilful resetting of government priorities through taxation and subsidies can alter the relative prices, and hence attractiveness and viability, of linear and circular economy goods and services.

Taxes: re-balancing rather than increasing the burden?

However, the journey from the old fashioned linear model to an ecotax system is also fraught with obstacles. Psychologically, the public has a conservative attitude to tax: it's more likely to accept the burden of a tax that has always been levied, and more likely to chafe at a tax that's brand-new. Aside from the shock of the new, ecotaxes face a struggle for acceptance for other reasons. They're highly visible: they're levied on specific things, and can therefore be blamed for preventing specific activities. This makes them different from income tax, for example: people may well complain that a high petrol tax, makes it harder for them to drive; they are less likely to complain that a high income tax does so. In common with most taxes on consumption, these ecotaxes also place a relatively higher burden on the poor than many other taxes, including income tax. That's because they're levied at a flat rate, and because the poor consume proportionately more of their income than the rich. This is all the more sensitive for low-income people because income inequality has risen in many countries. A good illustration of these points is the gilets jaunes movement that began in France in 2018, as a protest initially mainly by working-class people against the latest annual ecotax on fuel, used to fund eco-friendly projects. It then broadened out into a generalised movement against inequality.

Such obstacles to a more eco-friendly tax system can be overcome – by using the money from eco-taxes to reduce income tax for those at work but less well off, or creating a universal basic income, for example. Experts have given much thought to this problem, to the point of giving the conundrum its own name: the Just Transition. However, getting this right requires acute political antennae, and a more gradual and cautious approach than many eco-activists would like. That is all the more reason to begin now. Moreover, the massive increase in national debts because of the coronavirus crisis will always tempt governments to take money away through eco-taxes with one hand and not give it back with the other.

"Obstacles to a more eco-friendly tax system can be overcome."

A final circular economy challenge is the capriciousness of governments. Some circular economy projects, such as building renewable energy infrastructure, require heavy initial investment. That makes these projects viable only if they can be confident of a good price for their energy for many years. Abrupt cuts to Spanish subsidies for renewable energy after the Global Financial Crisis, when the state coffers were hit by recession, triggered lawsuits from providers that saw the viability of many projects threatened.

Paradise Found?

How can investors benefit: riding the circular wave?

Investors can be an obstacle to the circular economy, but they can also help bend the straight line into a circle. They can invest both in established businesses changing their models, and in "cleantech" companies that exist to help both businesses and consumers make the transition to the linear economy. Investors with large stakes in companies can also act as effective activist shareholders, pressing for a faster corporate journey towards circularity.

Providing finance for circular economy start-ups or initial public offerings creates a direct link between investment and outcome. This allows investors to help good circular economy ideas get off the ground and gather speed. Investing in funds that buy the shares of already listed circular economy advocates is also genuinely helpful: a share price supported by investor interest provides companies with the capital to make mergers and acquisitions.

It's also Candriam's conviction that investors have a chance to make long-term returns that outpace stock markets as a whole by investing in circular stocks. Harvard Business School has found that firms with good ESG performance "significantly outperform firms with poor performance on these issues, suggesting that investments in sustainability issues are shareholder-value enhancing"[14]. We go further, than this, however: we believe that circularity will become the new paradigm, with circular businesses becoming the biggest stock market winners of the future.

"Some will be Transformers; *some will be* Enablers."

Sceptics might consider the example of the US tech stocks that have provided shareholders with such stellar returns over the past decade – in particular the Faangs: Facebook, Apple, Amazon, Netflix and Google. These companies' stock prices have defied gravity not because of hype, but because they've profited from the transformation of humanity from analogue to digital beings: Humanity 2.0. Candriam believes that because of the circular economy megatrend, companies that establish circular leadership will be the Faangs of the coming era. Their journey to the top will be eased by the intense desire of policymakers to see the rise of the circular economy, and coming changes in both consumer and corporate behaviour. If we imagine the eventual stock market peak for well-run circular companies as like reaching the top floor of London's 95-storey Shard, Western Europe's tallest building, we're probably presently only at about the 10th floor. It's best to get into the elevator before we reach the 20th floor, or higher still.

Spurring the circular market trend

We strongly believe that once investors have thought carefully about what the circular economy is and how it works, it is possible to encourage a switch to a more circular economy through asset allocation decisions. Some of the obvious candidates for investment will be "Transformers", companies reshaping their own operations and supply chains to become more circular. Some will be "Enablers", companies that help the Transformers achieve this. Examples of well known Transformers include Xerox and Smurfit Kappa, while Enablers include Tomra and Vestiaire. Some companies can be categorised as both. For instance, Umicore has transformed itself from a polluting mining company by switching to new fields such as Recycling. In assessing these businesses, it is important to hold companies to exacting standards as circularity must be core to their business.

For example, it is not enough for an investee company to use a little more Recycled material than its competitors, and leave it at that. Circular thinking needs to be core to the design of products and services. This includes the substitution of polluting with non-polluting materials, the minimisation of virgin materials and non-renewable energy, and the good management of any waste that's unavoidable. Moreover, this must be a continuous process by which the company constantly questions its previous ideas of what's possible.

Striving for a sustainable circle of life

A realisation that the global system is under too much pressure has greatly increased interest in the circular economy. Legislation, regulation and tax changes in many countries across the world are reminding even reluctant businesses that they have to move away from the linear economy. That's the take-make-use-waste model, where no one worries about the exhaustion of materials or negative externalities that poison or deplete the environment. Investors can both benefit from the trend and help it along its way.

The move to circularity has to be all-embracing. Better use of raw materials is essential. This includes using more renewables and Recycled materials, and using land more efficiently by cutting down on meat and dairy. Product design will have to consider both physical characteristics and marketing aimed at boosting emotional durability. Consumers must grow used to Reducing consumption by repairing rather than discarding products, with the aid of the product manufacturers. Recycling is important in "closing the loop" – creating a circular economy with the Recovery of as much resource as possible. However, in the Lansink Ladder, a symbol essential to understanding the circular economy, it's only Priority Number Three, below Reduce/Avoid and Reuse.

"We don't know the future innovations... Society has proved ingenious."

The journey to a circular economy will be no easy route march along a smooth, paved road; it will instead be a hard slog along rough terrain. It will require new business models, a shift in consumer behaviour and consumption patterns, and the ingenuity and inventiveness of cleantech. Some of these models, such as sharing economy ideas, are in their infancy in many sectors. Moreover, the law of unintended consequences has not always been considered. This shown by a linear economy outcome of a circular economy idea: the bicycle graveyards in China, created by the discarded products of bike sharing companies.

The move to the circular economy also requires great political skill. Unless done deftly, it will cost some citizens – many of them poor, and increasing numbers of them highly vocal – more than others. It will also involve cutting down on some things that developed nations have grown used to over a generation or two, and that the emerging markets middle classes are only just beginning to enjoy. This includes daily meat and cheap flights whose price doesn't take into account their cost in natural capital. We can't innovate our way entirely out of trouble – moving the world to a circular economy is about giving up as well as thinking up.

We don't know precisely how the world will make the transition from a linear to a more circular economy, because we don't know the future innovations that will make this possible. Society has proved ingenious at finding solutions at different rungs of the Lansink Ladder, at different points, if the need is urgent. For example, the abrupt oil price rises of the 1970s greatly accelerated declines in energy intensity: the amount of energy used for each dollar of GDP. In the US, it fell by about 1% a year between the 1950s and early 1970s, but has since diminished at about double that rate[15]. The decline happened not just in deindustrialising countries such as the US, but also in industrialising nations such as China. These advances are primarily a triumph for the Reduce part of the Lansink ladder, and are not captured in Circle Economy's statistic that the world is only 8.6% circular.

We suspect that the change will come sooner than many people think, spurred by a sense of urgency and enabled by innovation. If we don't want the whole world to end up like Nauru, we need to think in a circular way.

Case Studies: Pursuing a circular business model

Tomra, based in Norway, is the dominant world supplier of reverse vending machines. Every year consumers put about 38 billion bottles and cans into Tomra's 82,000 devices, in return for their deposit. This is a growing market, as more countries introduce deposit systems to encourage consumers to Recycle. Tomra also has 60% market share of sensor-based systems for processing waste for Recycling and Recovery – a rapidly growing market. In addition, the company makes sensor-based sorters for the mining industry, which can trim the industry's energy consumption by 15%, as well as Reducing the water used.

Corbion is a Dutch food and biochemicals company that has declared its adherence to the circular economy. As part of its manufacturing process, it uses energy from renewables, biomass and non-fossil fuel feedstocks such as wood chips. Corbion has also a created a "responsible sourcing" initiative to establish a sustainable supply chain for its agricultural raw materials, and a "responsible operations" initiative that aspires to zero waste in the workplace. It uses palm oil, which is often the cause of rainforest destruction to build oil palm plantations, but Corbion checks that this is sourced responsibly.

Smurfit Kappa is a British manufacturer of paper-based packaging. Three-quarters of raw material is derived from Recycled fibres, with the remainder from sources certified by independent bodies as responsibly sourced. Packaging is made entirely from Recyclable material, which can make that journey six to eight times before being used to Recover energy. More than 90% of the material used is reinjected into the supply chain.

Umicore has transformed itself from a miner into a cleantech specialist. This Belgian firm manages a large metals Recycling operation. It has developed breakthrough technologies for Recycling lithium-ion rechargeable batteries, but also has expertise in Recycling the precious metals in jewellery, and in the technology of waste incineration and Recycling.

Xerox, the US manufacturer of printers and digital document devices, has a long history of remanufacturing. When products are returned, each part is checked using technologies including "signature analysis". That's where the noise, heat and vibration properties (the "signature") of the part are tested to confirm that it falls in the range characteristic of a "new" part during operation. Parts with acceptable signatures move to the next step; parts that fail this test are Recycled for use in another process. Supporting the circular economy starts with maximising the potential for Reuse when designing the product.

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