The power of digital technologies to enable the circular economy

Digitalising material flows

Ellen MacArthur Foundation

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Steel is not infinitely recycled. For instance, much of the high-grade steels recovered from vehicles are down-cycled into a lower-price material and mostly reused in lower-grade applications, such as buildings and infrastructures. Indeed, not aware of the quality of the steel they collect, recyclers mix different steel grades, producing a lower-quality recycled material.

Steel recyclers are not alone having little information on materials or products they recover. Plastic recyclers are not always aware of the full chemical makeup of materials they process, including the presence of toxic substances. Repair technicians don't always have access to disassembly guidelines for electrical equipment. Remanufacturers may not know the number of operating hours of an electric engine to decide if the engine can be restored 'as good as new' or whether it should be recycled.

To maintain the value of a product in the economy for as long as possible, information on the product design, composition, and condition is critical. With this information, an end-of-life product can be converted back into a valuable resource. In the transition to a circular economy, the equation is no longer "waste = resource" but "waste + information = resource" or, as stated by Idriss J. Aberkane, "waste + knowledge = asset".

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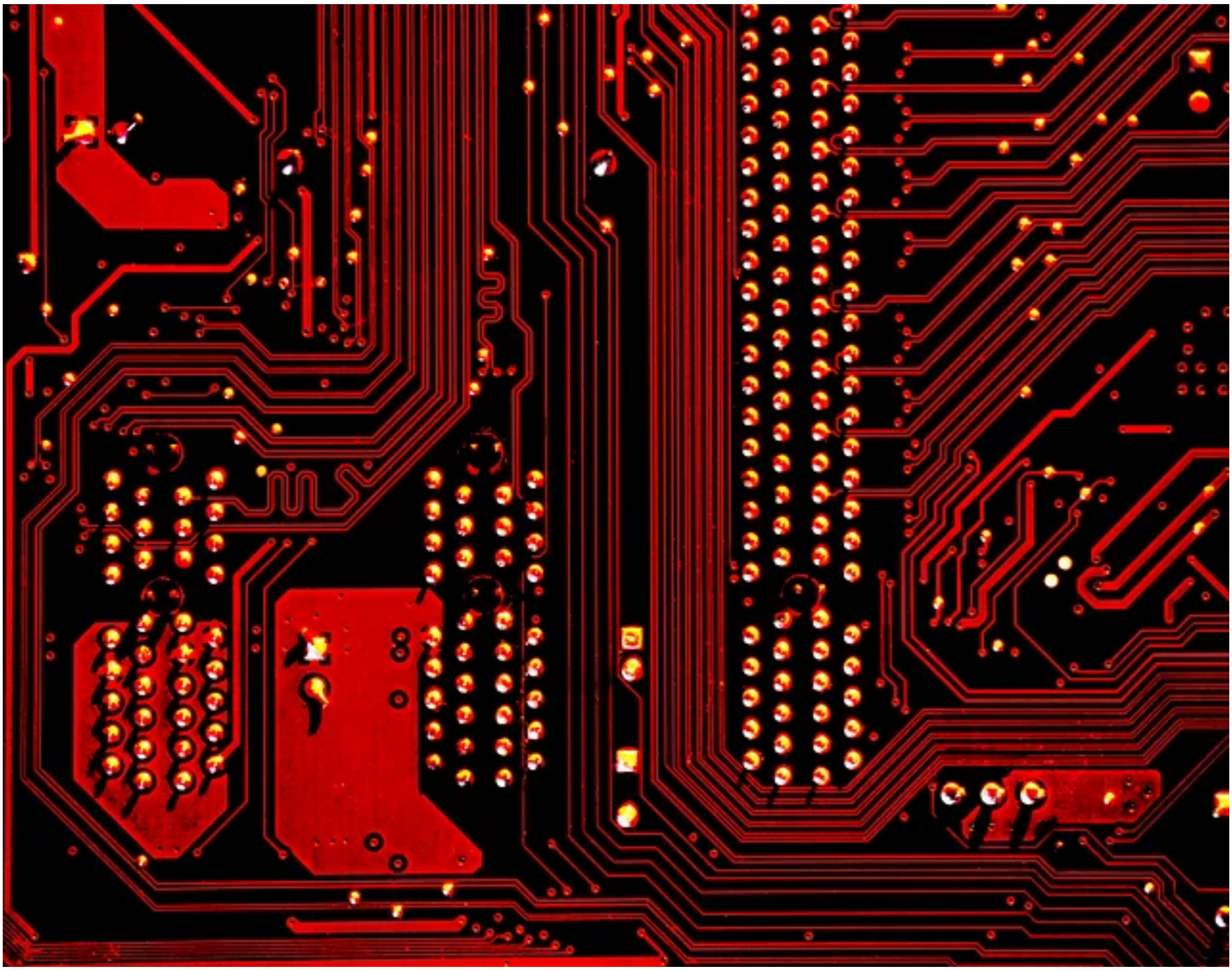
Leveraging digital technologies

Today, various digital technologies enable information to travel with a product. These technologies allow us to identify a product and capture, store, share and analyse data throughout its lifecycle.

To identify and track a product, two types of technologies exist: attached or embedded anchors. These anchors can be physical (such as fluorescent markers or watermarks), digital (such as Radio Frequency Identification or printed electronics), or biological (such as chemical tracers or DNA markers). For example, P&G is experimenting with digital watermarks, imperceptible code the size of postage stamps covering the surface of consumer goods packaging, that can be detected and decoded by a standard high-resolution camera on a waste sorting line. Another example is office furniture company Ahrend, which uses a QR code to identify each piece of furniture in their product as a service range.

Once a product is identified, data regarding its design, condition or location can be retrieved and information can be updated using various technologies. Data capture technologies include sensors or computer vision. For example, robots from ZenRobotics can sort post-consumer mixed material streams through computer vision techniques. Data transmission technologies include Wi-Fi, cellular network, Bluetooth and Low Power Wide Area Network to name a few. The construction equipment manufacturer Komatsu uses satellite communication to collect condition and location data of its machines. Data storage and sharing technologies range from cloud, digital platform, distributed ledger or big data. Thyssenkrupp collects and stores in the cloud operating data of 130,000 of its elevators worldwide to monitor their condition.



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Finally, thanks to data analysis technologies, such as artificial intelligence (AI), the capture and exploitation of these, often large, amounts of data are made possible. For instance, technology company Optoro offers a solution using AI to help retailers and brands manage, process, and sell returns and excess inventory through the highest value channel. Tomra, a manufacturer of advanced collection and sorting machines, uses artificial intelligence to analyse images and data from cameras, near-infrared spectroscopy, X-rays, and lasers, sorting waste according to their highest value and best use.

Many firms already leverage digital technologies to manage their products' information. Still, this information is barely shared along value chains, and as a result, most stakeholders don't have access to key product data. For example, to extend tyre lifecycle, manufacturers equip them with sensors measuring pressure and temperature, but they don't share information with collectors and processors that could help improve recycling or increase the uptake of recycled rubber in new tyres. Thus, due to a lack of opportunity for material valorisation, Europe exports more than 50% of end-of-life and second-hand tyres. Information technology is a key enabler for the transition towards a circular economy, but data sharing across the value chain is also crucial.

Standardise and share data along the value chain

To exchange data along the value chain, stakeholders need to agree on a common language. For example, several businesses from the fashion industry, including H&M, Target and I:CO, have agreed to use a common protocol, called Circularity ID, to share information on garment lifecycle. In France, GS1, an organisation that develops standards, and Citeo, an Extended Producer Responsibility organisation for packaging, worked with brands to support information exchange related to packaging, such as consumer sorting instructions. Driven by the Luxembourg Ministry of the Economy and supported by major international industry companies, the "Circularity Dataset Standardisation Initiative" aims at establishing an official standard for communicating data on the circular economy properties of products. In Germany, R-Cycle, a cross-industry consortium, is working on an open and globally applicable tracing standard to ensure the seamless documentation of recyclable packaging along the value chain, based on GS1 standards.

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Product passports are a convenient solution to establish a common protocol and share information on the origin, durability, composition, reuse, repair, and dismantling possibilities, and end-of-life handling of a product. For example, the shipping company Maersk Line has developed, in partnership with its suppliers, a “Cradle to Cradle Passport”, which lists and describes the materials used to build their vessels, their location, and how they can be correctly disassembled and recycled or disposed of. Maersk Line estimates that the passport will increase end-of-life vessels value by 10%. The European Commission released a new legislative proposal stating that all batteries (portable, automotive, electric vehicle, and industrial), with some exceptions, should have a battery passport. This would enable second life operators to take informed business decisions and allow recyclers to better plan their operations and improve their recycling efficiencies, because it would improve battery sorting, the health and safety conditions of operations, and even has the potential to increase the purity of the recyclable fraction.

If most passports are designed at product level, there are some examples of passports at material level. For example, global steel company SSAB offers a traceability tool called SmartSteel 1.0 that gives steel a digital identity. Customers can identify steel products by scanning its identifier, examine material properties, and download certificates.

Once data has been standardised, stakeholders often choose to exchange it using digital platforms. For instance, producers of electrical and electronic equipment use an online platform, the Information for Recyclers Platform (I4R), to share information regarding their equipment with recyclers, and to comply with European legislation. Several large automotive companies have established the International Material Data System, a global data repository that contains information on materials used in the industry that facilitate the recycling of end-of-life vehicles and their materials.

Many digital platforms are also used to support the trade of secondary raw materials. These marketplaces allow secondary material suppliers and buyers to find each other on a web-based platform. They are supposed to create more market liquidity and to provide more supply and demand security for recyclers and their customers. Many marketplaces specialise in specific materials, such as plastics (Scrapo), textiles (Nona Source), construction materials (Backacia), metals (Metalshub), or organic wastes (Organix), while some others cover multiple materials (Recykal). At one point, the World Business Council for Sustainable Development identified more than 100 marketplaces, most of them operating at a municipal or regional level, but most of them are failing to attract a large number of suppliers or customers. Many made the faulty assumption that "if we build it, they will come", but attracting a critical mass of both buyers and sellers can require significant investments.

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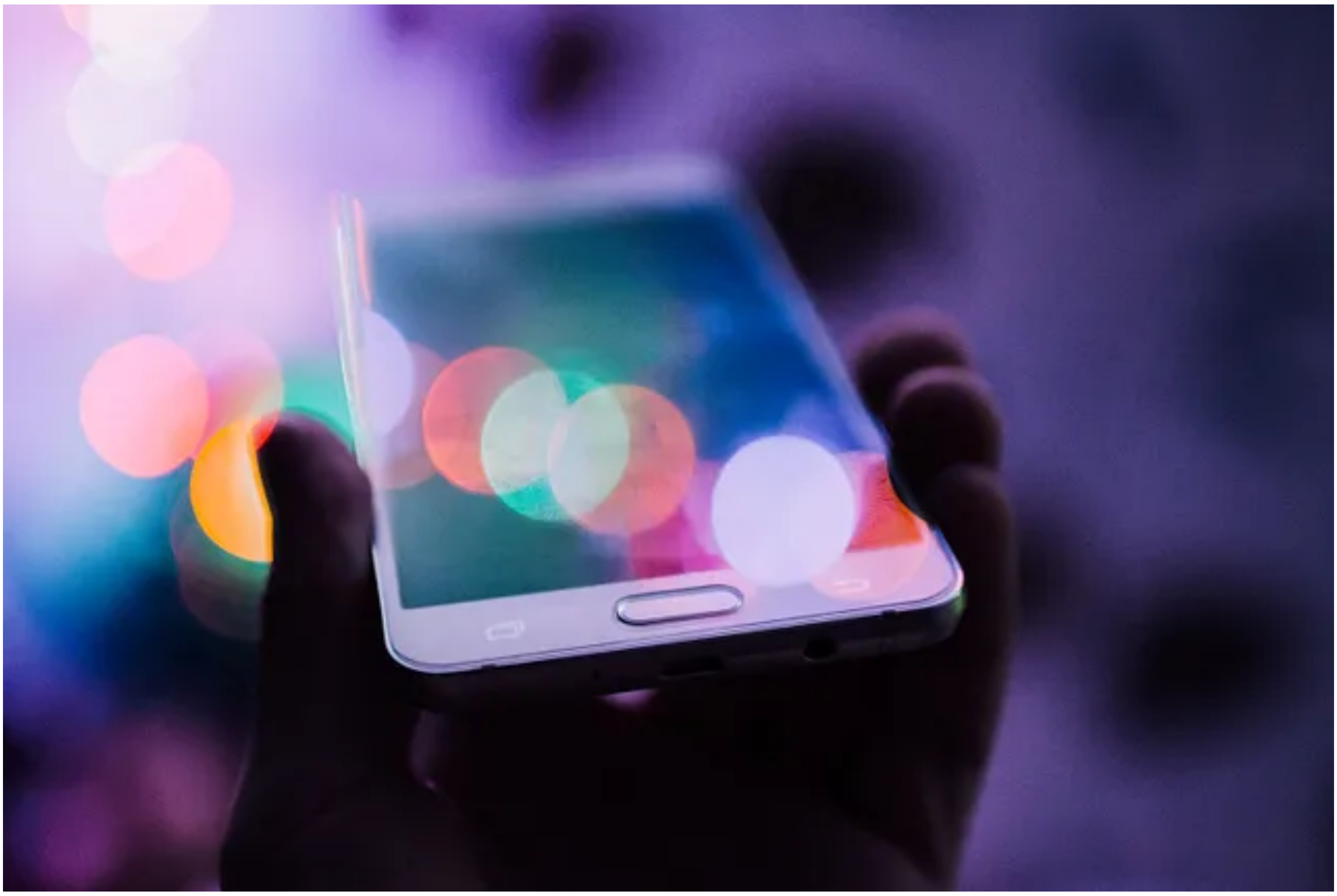
Stakeholders could also be reluctant to share data on a platform that, most often, is managed by a private company. Distributed ledger, the parent technology of cryptocurrencies and blockchain, offers an alternative technology that could address this concern. A distributed ledger is a type of database that is shared, replicated, and synchronised among the members of a decentralised network. For example, in France, organic waste producers, carriers, and farmers share information on the organic value chain using a blockchain, ensuring the transparency of the organic waste value chain and, at the end, delivering traceability of the fertiliser produced.

Many companies from the chemical value chain are experimenting with blockchain technology to improve the traceability of chemicals in general, and plastics in particular, through their lifecycle. Mitsui Chemicals and IBM Japan are working on a resource circulation platform using blockchain technology that should ensure traceability throughout the resource life cycle, from raw materials like monomers and polymers through to the manufacturing, sales, use and recycling of products. Borealis, Covestro and Domo Chemicals have launched a blockchain traceability project, together with Circularise and Porsche. Solvay has begun testing blockchain technology to trace its products throughout the entire value chain in partnership with Chemchain.

Blockchain can also be used to share data with consumers. Using blockchain technology provided by Provenance, Royal Auping has created a Product Passport that describes all the materials that go into their mattresses. The passport can be viewed by scanning an NFC (Near Field Communication) chip on the mattress label with a smartphone, allowing shoppers to view it in-store or at home.



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Ensure benefits are not offset by environmental costs

Digital technology is an opportunity for the transition towards a circular economy, but it is not a blanket solution and it comes at a cost for the environment. Indeed, digital technologies are responsible for resource depletion. Between 1995 and 2015, the material footprint of digital equipment has quadrupled. The extraction of the raw materials used in this equipment, such as precious metals or rare-earth elements, causes severe environmental damage, including land degradation, water scarcity, and biodiversity loss. Most equipment generates a lot of waste. For example, the production of a 3 kg laptop generates 1,200 kg of waste. The short renewal cycle of these types of equipment also causes large amounts of waste. In addition, according to some estimates, digital technologies account for 3.7% of global greenhouse gas emissions. In France, digital technologies could be responsible for 7% of total greenhouse gas emissions in 2040. And it is worth noting that, over the past 50 years, the development of digital technologies has coincided with the rise of CO2 emissions.

The belief that environmental costs of digital technology can be offset by the gains they could render is still to be confirmed. Therefore, before investing in new digital technologies, industries will have to validate that the negative impacts throughout the technologies' lifecycles do not offset the expected gains.

Start by building a roadmap

The transition toward a circular economy is unavoidable. Digitalisation of material and product flows is a major enabler of this transition. Therefore, businesses, industries, and governments alike should start by building digital roadmaps to answer key questions such as: What are the information gaps that prevent the execution of circular strategies? Which stakeholders along the value chain could share these data? Which are the enabling digital solutions to close the information gap? Will environmental costs of these digital technologies be offset by the gains they would render possible? Which open data format should be adopted?

We will not maintain the value of materials and products in the economy for as long as possible until we know what they are.

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