Artificial Intelligence of Things as an Accelerator of Circular Economy in International Business

Ghoreishi Malahat, Treves Luke, Kuivalainen Olli

DOI: 10.1007/978-3-030-95527-4_6

Artificial intelligence of things as an accelerator of circular economy in international business

Malahat Ghoreishi, LUT University, Malahat.ghoreishi@lut.fi

Luke Treves, LUT University, Luke.Treves@lut.fi

Olli Kuivalainen, LUT University, Olli.kuivalainen@lut.fi

Abstract: One of the key factors which influences the future of global economy is resource scarcity and the way businesses, policy makers and environmental scientists respond to climate change by finding solutions for reducing the use of finite natural resources and eliminating waste. With resources becoming scarce, businesses need to rethink and redesign the processes of designing, manufacturing, and delivering products and services. Businesses are responsible for creating products with longer lifetime which use fewer natural resources and are designed for repairability and recyclability. A circular economy model which focuses on designing out waste and pollution, regenerating natural resources, and keeping the materials and products in use offers a means to address environmental problems. In this scenario, businesses redesign their business models according to the principles of the circular economy, which also influences how they conduct international business operations. How internationally operating businesses organize their operations is not only affected by its environmental conscience and need for ecological reconstruction, but also technological advancements. With an increasing use of data and information in businesses worldwide, the opportunities digital technologies offer can increase businesses' environmental sustainability development. Through the utilization of digital technologies, businesses can gain detailed insight into their environmental impacts by transferring, storing and analysis of data related to circular economy indicators and set goals to achieve greater circularity. This chapter aims to explore the complementary role of Artificial intelligence (AI) and Internet of things (IoT) in improving circularity goals, and how developing artificial intelligence of things (AIoT) in organizations results in more efficient international business.

Artificial intelligence of things as an accelerator of circular economy in international business

INTRODUCTION

The international business environment is being shaped and transformed by several trends and megatrends. The latter typically extend over generations and describe complex and systemic interactions, such as climate change (Miles, Saritas and Sokolov, 2016). In this chapter we focus on two megatrends, (1) the urgency of ecological reconstruction (especially development of circular economy, CE) and the integration of digital technologies, especially artificial intelligence of things (AIoT); into all areas of a business, and (2) how they affect and change business models and consequently international business operations – so-called digital transformation. Although the role of IoT and AI has been separately researched and discussed in the context of CE and international business, how the integration of these two technologies can enable the transition towards a CE is an under-researched topic. Consequently, there is currently a gap in academic and practical knowledge on this prominent issue. This chapter defines the AIoT concept as an enabler of CE in an international business context, particularly from the perspective of global value chains and business ecosystems. In addition, this chapter aims to explain how businesses can adopt and integrate AIoT to help them achieve their CE goals as well as enhancing circularity in their business ecosystems. The chapter also provides examples of businesses who are successfully implementing AIoT in their businesses the impact that it has had on their activities. Finally, we explore how international businesses are organizing their operations from the perspective of environmental conscience, the need for ecological reconstruction via business model innovation (BMI), and the role advancements in digital technologies play in achieving this. This chapter is structured as follows: first we discuss the significant role of BMI in CE and International business (IB), and then how the integration of disruptive digital technologies, including AI and IoT; is enabling businesses to redesign their existing BM's incrementally or radically, in transition towards a CE whilst advancing their international business activities.

BUSINESS MODEL INNOVATION and CE

The Emergent Role of Circular Business Innovation:

The concept of a "business model (BM)" describes the design or architecture of a business's mechanisms to propose, create, deliver, and capture value (Teece, 2010), for itself and its stakeholders (e.g., partners, suppliers, and customers). The BM is often depicted as a value proposition offering product/service, value creation and delivery, and the mechanisms of how value is captured (Margaretta, 2002). In addition, BM extends the concept of the (global) value chain by (1) emphasizing value creation and delivery dynamics, (2) extending across business and industry boundaries, and (3) allowing for a non-linear sequencing of independent activities (ibid). In their "Megatrends 2020 and beyond" report, EY (2020) articulates that the biggest growth opportunities might go to those businesses that can create new business models, also referred to as BMI, based on their customers and supply chain behavioral data (behavioral economy). This is of significance as consumers are increasingly demonstrating a hunger for innovative and novel approaches to satisfy their individual needs and demands, which are built on foundations of empowerment and engagement rather than exploitation and alienation (EY, 2020; p.42).

BMI typically can occur in two forms, designing an entire new BM or reconfiguring the elements of the existing BM which as a result increases the competitiveness of businesses (Massa and Tucci, 2014). BMI can be considered as a repetitive process such as ideation, implementation, and evaluation involving various levels of details (Wirtz et al., 2016). Geissdoerfer et al. (2018) succinctly describe this process involving *"… the development of entirely new business models, the diversification into additional business models, the acquisition of new business models, or the transformation from one business model to another. This transformation can affect the entire business model or individual or a combination of its value proposition, value creation, and value capture elements, the interrelations between elements, and the value network (p. 406)."* BMI is often represented as a transformational process (He and Ortiz, 2021) through which a business moves from one BM to an entirely new BM (Osterwalder and Pigneur, 2010), significantly more developed and advanced one (Chesbrough, 2007), or a different and integrated BM (Geissdoerfer et al., 2018). The motivation for BMI is twofold: (1) fulfilling a previously unmet needs of an existing customer base through value creation, or (2) a desire to develop a new customer base(s) through new value creation, and the capture of mechanisms and activities (Haaker et al., 2021). This highlights that the concept of value is the core in BMI.

CE business models have been identified in the literature as one type of SBM (M. P. P. Pieroni et al., 2019). SBMs integrate three aspects of sustainability (economic, environmental, and social) to the value proposition goals of the businesses both at the organizational level and at networking level. The process qualifies as a sustainable BMI, when it has following aims: 1) sustainable development or positive, respectively reduced, negative impacts for the environment, society, and the long-term prosperity of the organization and its stakeholders or 2) adopting solutions or characteristics that foster sustainability in its value proposition, creation, and capture elements or its value-network (Geissdoerfer et al., 2018, p. 406). Since in CE the goal is to create various forms of value by achieving higher efficiency of resources and a well-organized economic system (EM Foundation, 2015)CE BMI includes CE principles and strategies as a guideline for BM design. The integration of CE principles into BMs happens at various levels which depends on decision maker's aspirations as well as selected approaches. BMI contributes to CE by moving towards businesses developing more sustainable orientated business models (SBMs). Some authors address environmental, social, and economic challenges which CE tries to theorize by integrating the economic activities with environmental and societal wellbeing. This has led to CE being considered as an important part of sustainable development, and as a concept that operationalizes or substitutes it (Bocken et al., 2014; Boldrini and Antheaume, 2021; Kirchherr et al., 2017; Merli et al., 2018). CE BMI can be an extension or sub-category of traditional BM and SBM definitions with their specificities connected to the circularity approach (Boldrini and Antheaume, 2021).

In circularity, value creation is related to reverse logistics, which enables retaining value and restorative value proposition (Reike et al., 2018). Various processes of production, distribution and consumption activities must be considered in loops (Lieder and Rashid, 2016). In addition, to make such supply chains viable, customer needs and demands should be strongly taken into account (Kirchherr et al., 2017). Return loops enable improvements in resource efficiency in two ways. Firstly, they support the return of valuable and functional components and materials to the manufacturing process that would previously been discarded, reducing the need for extraction of new natural resources. Secondly, they enable the prolonged maintenance and utility of valuable products, components and materials which can increase value for companies and the economy more broadly. Additionally, businesses can implement strategies such as:

extending the useful life of products, intensifying the use of a given product (pooling, sharing, leasing), or dematerializing it (services, digitalization) (Geissdoerfer et al., 2020). This involves identifying cascading, meaning multiple cycles of value creation thanks to consecutive use of resources. CBMs are also interconnected and require communication and coordination between multiple independent but interdependent stakeholders nested within complex business/value (Antikainen and Valkokari, 2018) . While businesses are putting efforts to innovate CBMs, they need to consider how their business model will boost circularity, value creation, and value capture (Frishammar and Parida, 2018; M. de P. Pieroni et al., 2019).

ARTIFICIAL INTELLIGENCE of THINGS and CE

According to Sitra (2021), the use of digital solutions to measure, store and analyze data is a central element in CE solutions. Data-driven CE solutions not only boost and support business but can also help to generate completely new innovative solutions. Fig.1 shows the key role of data in CE and which technologies can be utilized in different CE solutions.

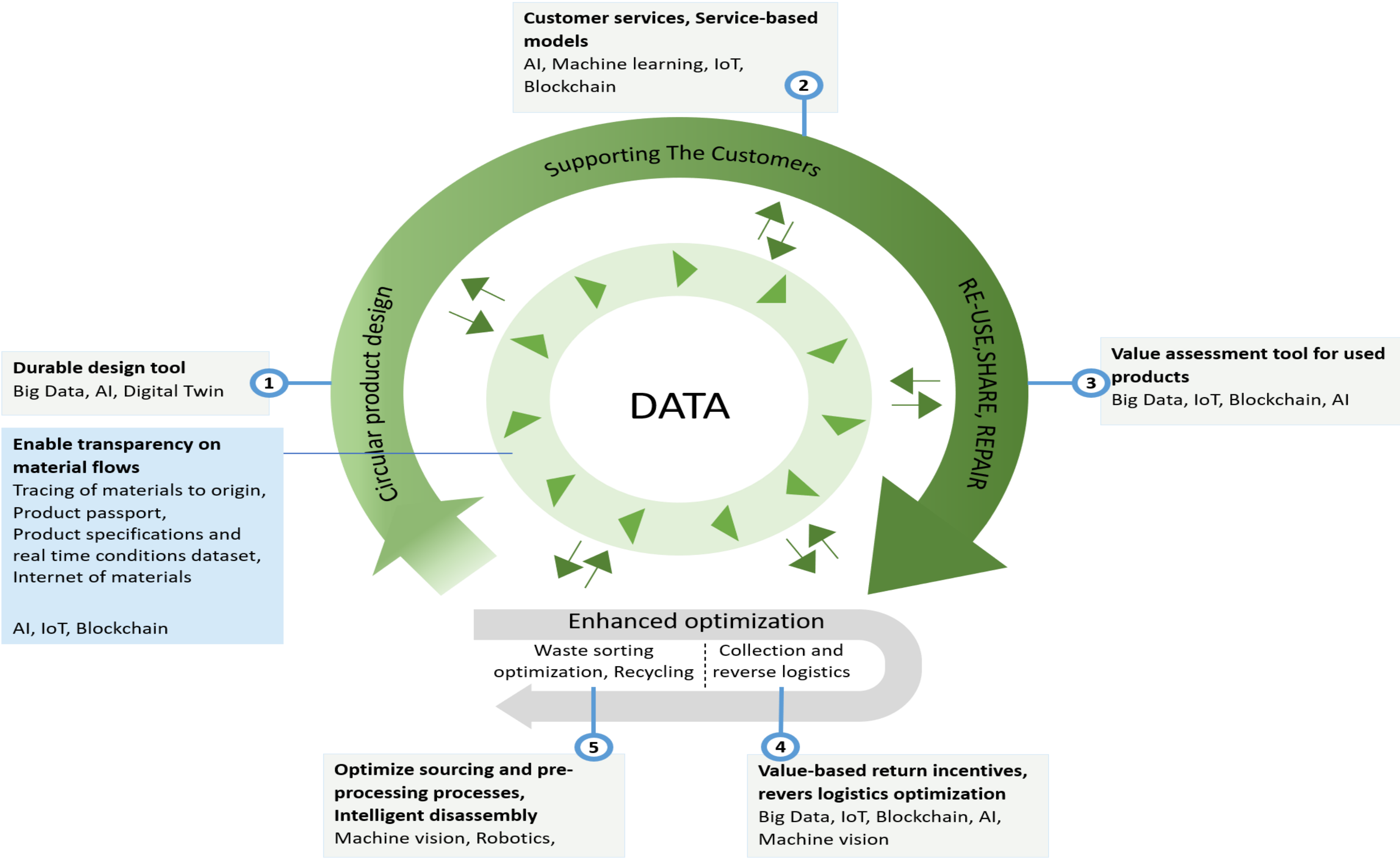

Figure 1. The role of Industry 4.0 technologies in CE (based on (World Economic Forum, 2019))

Industry 4.0 solutions can help businesses in tracking their material flows, measuring circularity and its impact, finding new business opportunities while optimizing resource usage, which leads to improving internal operations and profitability. Various businesses are focusing on solutions which are "all about the data", therefore their aim is to develop digital tools which support circularity. On the other hand, other businesses significantly focus on digital solutions to help the end consumers while collecting data for improved management and further development of their existing solutions. In addition, increasing accessibility and availability of data improves traceability of the network and business ecosystem, and increases social impacts of different CE solutions. Fig.2 presents a framework of smart CE based on Kristofferson, et al. (2020). The framework presents five levels of data transformation as follows:

- Connected resources: which includes products, materials and components which are connected for example.
- Raw data: which is based on the observations of objects, events and/or their environment which requires textualization to be valuable and usable data.
- Information: which is transformed from data, included in descriptions, and provides answers to *who*, *what*, *where*, and *when* questions.
- Knowledge: which represents the transformation of information into actionable instructions, know-how, and valuable insights, and answers questions such as *how* and *why*.
- Wisdom: which is the connection between actionable instructions of knowledge to independent decisions and actions. Wisdom is a combination of knowledge and interactive processes and adaptive judgement.

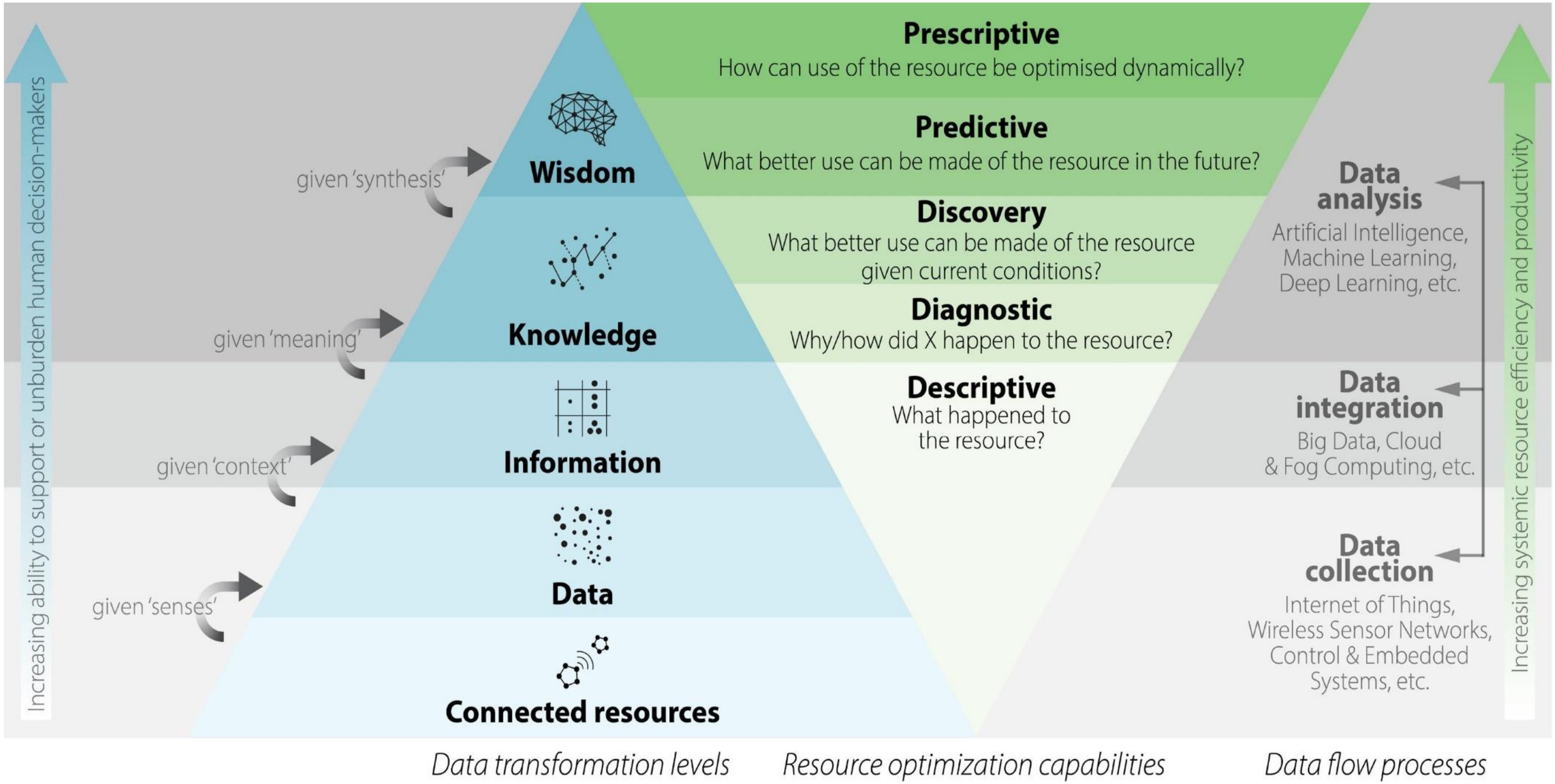

Figure 2. The framework of Smart CE (source: (Kristoffersen et al., 2020)

As illustrated in Figure 2, data flow processes show the interconnection between different digital technologies. Data flow processes include three layers: data collection, data integration and data analysis. In data collection layer, data is generated and gathered through devices and systems, enabled by technologies including IoT, wireless network sensors, and embedded systems. In the data integration layer, the data is processed, contextualized, and curated relying on context-awareness enabled by big data, cloud computing, and fog computing. The data analysis layer is the process of understanding the data to make decisions. This is enabled by techniques such as AI, machine learning, and deep learning to deploy data with meaningful insights and foresights. Furthermore, the framework illustrates five layers of resource optimization capabilities: descriptive, diagnostic, discovery, predictive, and prescriptive analytics. Each of these levels are aligned with digital technologies that can be utilized at each specific level. For example, descriptive capabilities seek to answer questions on "what is happening" or "what happened," and adds context to the raw data from IoT devices, thereby transforming information. Leveraging data as well as intelligent and smart use of resources enables CE in achieving sustainability goals by reducing the pressure of extracting finite resources. Digital technologies can support CE by creating, extracting, processing, and sharing precise and real-time data. The efficient utilization of these technologies is essential for organizations in their transition towards a CE. Supporting our observation, the EMF (2019) states that, "new technologies, including faster and more agile learning processes with iterative cycles of designing, prototyping, and gathering feedback, are needed for the complex task of redesigning key aspects of our economy".

AI and IoT has been identified as two high potential technologies that can enable and fuel the transition towards CE due to their capability of collecting, processing, interpreting, and applying data in meaningful ways with minimal human engagement through accessibility to wide range of data anytime and anywhere. The combination of these two technologies, which we call "AIoT", will enable businesses to improve their product optimization, operations as well as increasing financial benefits. In the following sections we illustrate the role of each technology (AI and IoT) individually as an enabler of CE and how the conjunction (AIoT) can improve the transition by providing examples of case companies who are utilizing AIoT in their business internationally.

AI as an Enabler of CE

AI is the collection of digital techniques which deal with models and systems that perform human-like cognitive activities such as reasoning and learning (McCarthy, 2007) . AI can boost and enable CE within various businesses by 1) designing circular products, components, and materials, 2) operating CBMs, 3) optimizing circular infrastructure (Ellen MacArthur Foundation, 2019). AI can help in optimizing and developing products as well as enhancing circularity of the products via machine-learning techniques that can be utilized in design processes which learn by iteration. Such processes allow faster prototyping and testing, consequently reducing the waste in these processes (Ramadoss et al., 2018). Furthermore, AI enhances circularity in products, and increases competitiveness of businesses through innovative BMs such as product-as-a-service. By combining real-time data from products, ervices and consumers with historical data, AI can be used in predicting precise price and demand, predictive maintenance, and smart inventory management (Ghoreishi and Happonen, 2020). On the other hand, AI can help in developing and improving reverse logistics infrastructure which is needed to close the product and material loop. In this regard, AI technologies can be utilized in improving the processes of sorting and disassembling of the products, remanufacturing components, and recycling materials. According to Ghoreishi and Happonen (2020), “AI helps in producing lifecycle prolonging results through modernizations so that the products can be repaired just before the break time and/or they can be repurposed into less taxing environments to prolong the use time even more than by just maintaining it in original installation place”. Different roles of AI in CE are presented in Table 1.

Table 1. Different roles of AI in CE (source: Ghoreishi and Happonen, 2020)

Role of AI in CE				
Eco design	**Maintenance**	**Customer Support**	**Asset recovery**	**Infrastructure optimization**
Circular product design	Smart Maintenance	Customer services	Intelligent assets	Recycling
Modular design	Remote monitoring	Digital platform	Refurbishment	Precise waste sorting
Fast, smart and precise prototyping	Product life cycle analysis by smart sensors	End-user need data analysis and prediction	Re-use	Add value to recycled and recovered materials
Failure and downtime reduction	Maintenance optimization	Product lifecycle extension by shared platform	Remanufacturing	Secondary raw materials
Material toxicity prediction	Real-time data transformation	Dynamic pricing, matching algorithms	Repair	
Cost reduction in testing		Collaborative decision-making		
Real-time data analysis		Data-enabled prediction		
Reduce energy in designing products				
Warehouse management				

IoT as an Enabler of CE

The Internet of Things (IoT) describes the network of physical objects— “things”—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. Allowing for the continuous collection and exchange data ‘any-time,’ ‘any-where’ and for ‘any-thing’ (Whitmore et al., 2015). This is creating opportunities for direct integration between the physical world and computer/internet-based systems, resulting in improved efficiency, accuracy, and economic benefits. The IoT has an important role to play in the CE, by enabling businesses to keep products in use in a way that makes money plus enhances the customer experience. Particularly, it can help organizations to understand:

- How their product-service components are being designed and manufactured in line with more sustainable goals, including using more sustainable and reusable materials as part of the build process.
- The origin of the materials to ensure their sustainable credentials, as well as reducing the impact of counterfeit parts.
- How to design products with reuse and repair in mind.

- How to reduce waste by checking water wastage and other materials used in the process.
- How to assess and take preventative actions to extend its product-service components lifecycle. (Porter, 2021)

Table 2 provides an overview of IoT's main capabilities, and how the data processes and sources they open to businesses, can enable CE strategies.

Table 2. IoT capabilities and their role in Circular Strategies (adapted from Ingemarsdotter *et al.*, 2020)

		Circular Strategies					
		Efficiency	Increased utilization	Product lifetime extension	Reuse	Remanufacturing	Recycle
IoT Capabilities	Tracking	Enables energy saving and optimization.	Services which allows tracking products.	Enables tracking products and parts installed at customer sites to enhance maintenance services.	Tracking used products, parts and materials helps identifying products that can be reused, remanufactured.		
	Monitoring	Enables energy usage and performance. (monitoring products' condition)	Enables utilization of facilities based on data from monitoring.	Enables condition-based and predictive maintenance and manage repairs. Enables storing data of installed products which facilitates maintenance.	Enables monitoring the condition and use of products to assess the reusability.		
	Control	Remote control enables save energy, optimize the system efficiency and comfort.	Enables remote controlling in sharing systems.	Enables remote maintenance, repair and upgrades.	Enables take-back system more effective.		
	Optimization	Performance optimization by monitoring condition of the equipment and environmental parameters.		Enables monitoring the performance and faults to optimize repair and maintenance services.	Enables monitoring the use cycles of products and parts can optimize the use times in multiple use cycles on the individual part level.		
	Design Evolution	Enables product redesign and improvement by collecting data about products' condition and reducing faults.	Enables improving service design by collecting data on usage of the services as well as reducing operational costs.	Enables durability of the products by providing data from products-in-use.	Enables supporting design of services related to recovery strategies for building business cases for looping.		

Collecting data from use phase of the products helps companies to continuously improve product design such as enhancing durability of the products (Bressanelli et al., 2018). In addition, digital components in products make the upgradability of the products easier and adds more functionality to the product which can extend the lifecycle of the product (Pialot, Millet and Bisiaux, 2017). Regarding the CE strategy to increase utilization, IoT enables monitoring of product condition, location, and status which supports product sharing between multiple users. In addition, data collected from in-use products can be used to improve strategies of recovery such as remanufacturing, reusing and recycling (Alcayaga, Wiener, Hansen, 2019). Precise estimations of a product's useful lifecycle support decisions on optimal remanufacturing time of a certain product and can improve the profitability of remanufacturing activities (Ingemarsdotter et al., 2020). Finally, regarding recycling RFID tags in products can increase efficiency in recycling processes as well as improving information on material composition to create profitable processes of recovery (Denuwara et al., 2019).

As illustrated already, there is no doubt that IoT brings enormous benefits and values to businesses. However, understanding the rich data collected by IoT technologies relies significantly on utilizing AI. AI can close the loop in an IoT environment, by capabilities of learning from the data collected by IoT and consequently automating important decisions and actions. Combining IoT data with external resources such as logistics and consumer insights, or the supply chain actors helps businesses in achieving next-level improvement in quality. Furthermore, applying AI to IoT data can effectively improve performance and insights. Consequently, AIoT can speed up operations as well as improving productivity while reducing costs. Utilizing AIoT can improve quality, maximizing equipment performance and improving efficiency. For example, managing fleet of power-generation assets is challenging and requires real-time insights from country to country. Many businesses are aiming to strongly operate, maintain and manage assets at the central level. By leveraging AIoT, these businesses can solve such challenges while gaining benefits such as quick review of the performance of power generation units in detail, reducing the time of analyzing the wind power generation, recognition of where the assets are unperforming and applying a quick maintenance to country technology teams, and improving production efficiencies.

AIoT case examples

USG Corporation is a building material leader in United States optimizes productions by utilizing big data (collected by smart IoT devices and sensors) and predictive analytics (statistical algorithms and machine learning techniques / AI techniques). Advanced data is essential in creating new products which keep the air clean and are eco-friendly as well as meeting the standards for coveted environmental ratings. Considering the high range of global competition, the business must produce high-quality products at an affordable price which requires confidently detecting, resolving, predicting, and preventing quality faults and reliability issues while minimizing costs. Utilizing AIoT techniques enables the optimal formulation in raw materials and adjusts the production process in real-time.

Volvo Trucks are using sensor data and AI solutions to minimize unplanned downtime. Unplanned downtimes can impose considerable damage and expenses on fleet operators and the customers where the delivery time is especially important. Unexpected breakdowns of the trucks can cause huge costs for the operators. Hence, Volvo has overcome this challenge by remote diagnostic and preventive maintenance services by utilizing IoT with AI. This solution can help Volvo Trucks customers to maximize a vehicle’s time on the road while minimizing the costs of service disruptions by servicing connected vehicles more efficiently, accurately, and proactively. Thousands of IoT sensors on each truck enables collecting real time data for remote monitoring services. Data includes the location and conditions during the fault. Then the massive amount of data is processed and analyzed by Analytical AI techniques to diagnose the fault quickly and detailed information and recommended action plans are provided to the customers.

AIoT ENHANCING CE in INTERNATIONAL BUSINESS

The rise of the internet and connected devices allows people and businesses to operate 24/7 365-days a year, across oceans and continents. This has reshaped, upended, and given rise to new industries, and changed how people interact with the world. Once barely more than a convenient, quick, and cheap way to send messages around the world, the internet now touches nearly every aspect of our lives (Velocity Global, 2018). The shift to more internet-enabled and intelligent products-services has gained momentum in recent years as the decline in cost, increase in processing power and a prevalence of sensors has made it possible to connect things, people, and devices across geographical boundaries. This is likely to have far-reaching implications for international business and commerce and is likely to drive generational shifts as industry lines are blurred and digitally inspired disruptors emerge (Evans, 2018). As an emerging megatrend, AIoT is forecasted to be a key driver in advancing this revolution by delivering intelligent and connected systems which can self-correct and self-heal themselves. AIoT creates a smart, connected network of devices that make faster, greater, and more efficient impact than ever, which in turn will give businesses and governments the ability to influence and shape not only domestic, but also international business like never before (EY, 2020) through a heightened awareness of the world, and smart tools that monitor and react to changing conditions often without human input. For example, deep learning capabilities of AI enables businesses to efficiently derive process and simulate business relevant insights and actions from the massive amounts of data captured from IoT systems through sensors, software and other technologies embedded within objects, which allows for the exploration of the real and virtual world in ways that have not been previously possible. This is of critical importance to businesses due to their increasing reliance on data to drive their decision-making processes. AIoT will prove invaluable for international business headquartered in one country with remote operations across the globe. Knowledge and its transfer have been seen as the core of multinational companies in the past already (e.g. (Kogut and Zander, 1993)); AIoT provides more opportunities to use knowledge stemming from various parts of the world, however.

As has been described, the value of IoT data can be only realized when combining with analytics and AI - AIoT. AI brings significant value and success from IoT initiatives within a business which heavily utilizes AI. The rich and wide range of data coming from the IoT requires understanding and ability of businesses to deliver value from data which can be interpreted by AI. In an IoT environment where there is vast range of data, AI can learn from this data and eventually automate decision making and close any loops. Integrating AI capabilities with IoT will increase reliability, efficiency, and productivity processes. AIoT can help in speeding up operations of improving employee productivity and decreasing costs by minimizing potential friction points in traditional (classical) operating models by reducing the number of actors needed in extended global supply chains. At the same time associated technologies like blockchain and automated systems (e.g., smart contracts and smart meters) can increase trust in operations and transactions due to their ability to remove human error and enable users to have a better oversight of their extended supplier/partner chain's as live status information accessible through platform systems becomes a prerequisite of international business.

Overall, smart contracts can lower transaction costs (cf. e.g. (Hennart, 1989) among different parties. This empowers business leaders around the globe to improve quality, maximize equipment performance, improve production efficiencies, anomaly detection, increase forecasting accuracy, inventory control from sourcing to delivery through more frequent use of small-batch "just-in-time" manufacturing, timely stock replenishment, balance energy, and operational efficiency, improve health and medical outcomes (SAS, 2020). Further, AIoT data analytics enables businesses to learn more about, audit, connect with their entire value chains, including their sub tiers and sub-sub tiers where most disruptions and non-CE activities are likely to originate (Sneader and Singhal, 2021). At the same time the data collected through these processes can be used by international businesses to influence and shape consumer behavior in increasingly precise and sophisticated ways (EY, 2020). These outcomes will have a significant impact on economic performance and CE aspects in sustainability, and international business.

An often-cited example of AIoT being used by industry is the international transport and logistics sector in which sensors are being applied for predictive maintenance in trucks. This not only allows for the automatic scheduling maintenance, but scheduling maintenance along the truck's route to keep it on track for its anticipated delivery date. If the truck requires a specific part, its system can alert an operator thousands of miles away, prompting him or her to order and ship the part to the desired service center—keeping the truck on schedule with minimal delay. This data can be managed anywhere in the world, making it an excellent way for businesses to keep operations running smoothly—even in another country. The concept applies to any global business that needs to keep track of its shipping, sales, maintenance, or any other need that can be addressed remotely (Velocity Global, 2018). Another example, AIoT CE application is in the international high-tech industry, which requires circular thinking to address issues like shorter shelf lives, planned obsolescence, and changing customer preference. This leads to tons of equipment to be discarded and replaced rather than repaired and reused. In the U.S alone 400 thousand mobile devices and 120 thousand computers are discarded each day, leaving enormous value on the table, loss of infinite natural resources and potential damage to the society and the environment due to the release of harmful substance or hazardous disposal methods. AIoT can be a used a tool to shift this current trend and improve international businesses circularity by enabling businesses and their extended supply chain partners to track and identify products from cradle to grave by efficiently managing products and components through secondary markets. This tracking also facilitates the development of new service-based sectors which can use data collected through AIoT to identify, extract, refurbish and reuse components that still have a useful lifecycle (SAS, 2019).

An innovative approach to international business driven by CE and AIoT

As international business and CE, becomes increasingly influence by these technologies, the adoption of an (business) ecosystem perspective to deliver products and /or services, through which a set of global actors (producers, suppliers, service providers, complementors, end users (customers), regulators, civil society organizations (Fig.3 and Fig. 4), contribute to a collective outcome (Jacobides et al., 2018; Talmar et al., 2018) through strategic alliances based on a hierarchical (Adner, 2016) or decentralized bottom-up approach (Karakas, 2009) is emerging. This allows ecosystem members to receive advantages and support from other actors who have the resources they need, e.g., product design and marketing expertise, supply route detail, production knowledge, and systems (Lewandowski, 2016). Further still, it allows members to focus on their core business and value creation competencies in a more sustainable way. This is breaking down traditional domestic and international boundaries by allowing internal (within business) and external (other stakeholders) ecosystem members to interact with each other anytime, anywhere and on anything, across extended global ecosystems. Whilst increasing the importance of awareness to and geographical nuances such as domestic and international laws and regulations, or cultural differences, which often need human input and can be overlooked when businesses and/or ecosystem become over reliant on digital technologies.

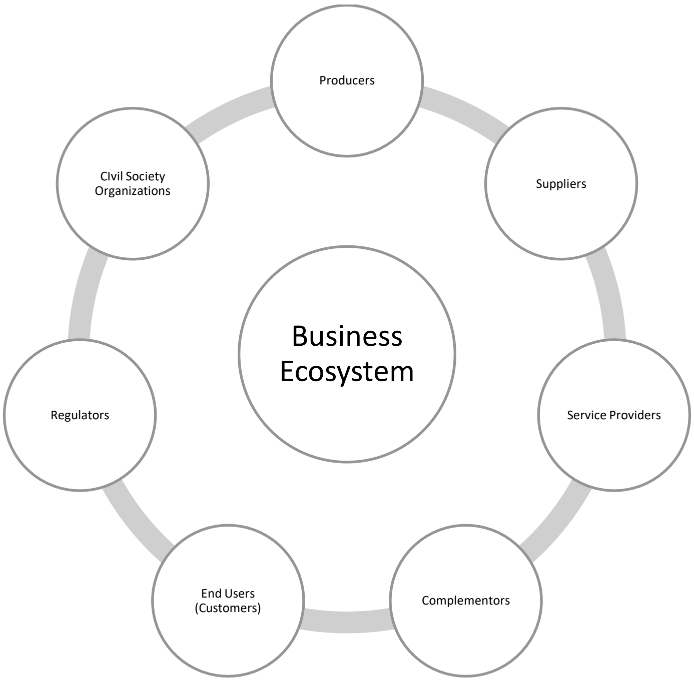

Figure 3. High-Level Representation of a Typical (Business) Ecosystem Membership Structure (Adapted from: Jacobides et al., 2018; Talmar et al., 2018)

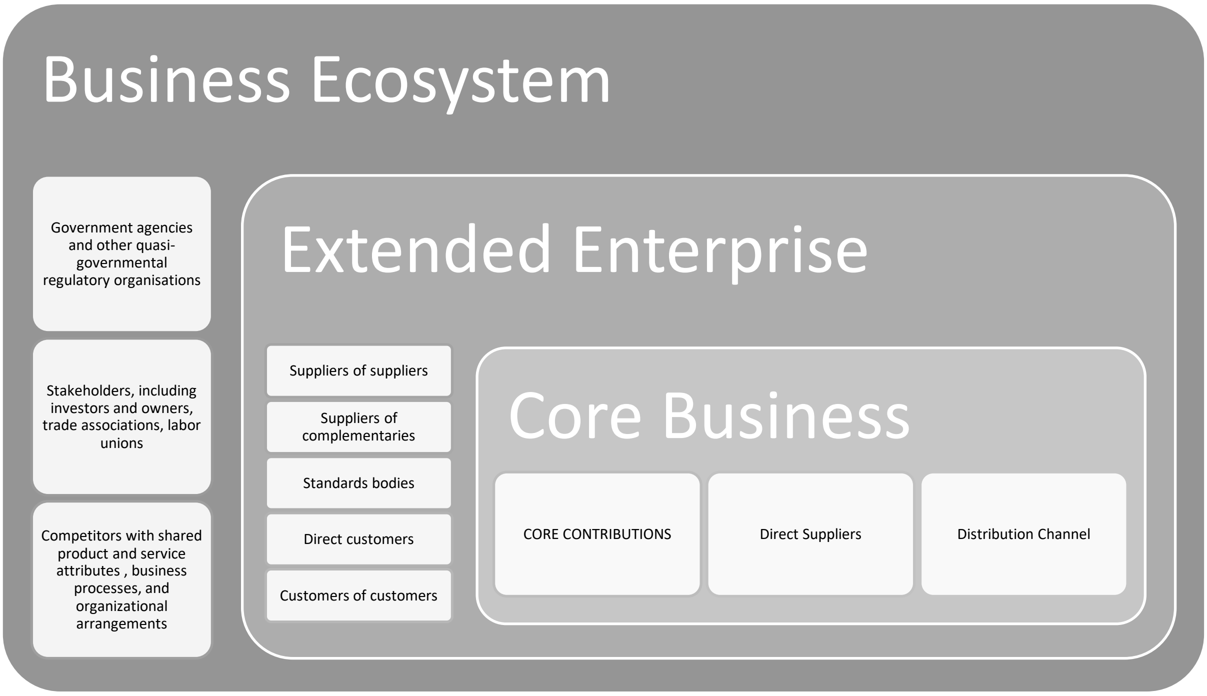

Figure 4. Moore's business ecosystem layers The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems (Adapted from Moore, 1996)

From a CE perspective, recent research defines these relationships as CE business ecosystems, which is broader than a pure business ecosystem. According to Aarikka-Stenroos *et al.* (2021), CE ecosystems are "*communities of hierarchically independent, yet interdependent heterogeneous set of actors who collectively generate a sustainable ecosystem outcome".* Konietzko *et al.* (2020) identify three main principles groups for CE ecosystem innovation as collaboration, experimentation and platformization. Collaboration group refers to the way firms' organizations interact with each other in their ecosystem to innovate solutions for CE. The experimentation group refers to the way organizations establish processes of trial-and-error to achieve greater circularity, whereas platformization group refers to the way organizations manage social and economic interactions through online platforms to reach their circularity goals. Regarding CE, Konietzko et al., (2020) hypothesize that to achieve circularity through an ecosystem approach, or so called "circular ecosystems," necessitate a systems perspective of circularity, rather than viewing it as the property of an individual product and/or service. Consequently, transitioning to a CE requires product, business model and ecosystem innovation. In this situation, the difference between a BM and an ecosystem perspective is that the latter views BMs of other relevant actors to be as important as the one of a focal firm (Adner, 2016). In these scenarios, circularity is seen to be the property of a system of actors and different contributions. It is the interplay of different actors, ecosystem and business model elements that together maximize resource efficiency and minimize resource use, emissions, waste, and pollution.

Geissdoerfer et al's. (2018, p.402) definition of BM and sustainable BMI capture the models as a value chain as follows: "as simplified representations of the value proposition, value creation and delivery, and value capture elements and the interactions between these elements within an organizational unit." If we consider this at the global value chain level, or at the ecosystem level, to better reflect the interconnected, inter-reliance and global nature of modern business ecosystems we need to consider several actors, some which provide AIoT technology. Utilizing AIoT in the CE ecosystem helps manufacturers to improve quality of the product by applying analytics and combining with IoT data from external sources such as supplier data, logistics and consumers. For example, one way to change the traditional value chain is the AIoT-enabled leasing model where both manufacturing capacity and final products could be leased based on data on usage and forecasts. Data plays an important role in all these principles highlighting the key role AIoT can play based on our earlier descriptions.

From an operational perspective, there are three distinct categories of CE ecosystems: the flow of material and energy, knowledge flow, and economic value flow, which would be like the flows in a networked multinational. Sitra (2021) mentions that successful organizations in CE establish and expand their circular business ecosystem from the very beginning to ensure their solutions respond to CE goals in the long term and suit customers' needs and satisfaction. Collaboration with larger groups of stakeholders and partners in an ecosystem therefore helps businesses in investing in more sustainable solutions and to develop CE solutions. In this regard, data plays a vital role in the ecosystem for collaboration and sharing information, knowledge, or experiences that organizations face during their path towards CE. AIoT can also help organizations find new business opportunities within their ecosystem and optimization of resource usage. Hence, it can help them to improve their operations and profitability internally and externally. This has given rise to a growing interest in AIoT BM's, which focus on the business environments that exploit digital technologies capabilities, and underscore the relevance of contextual issues, such as interdependencies, interactions, and partnerships that evolve in the same innovation ecosystem's (Haaker et al., 2021; Metallo et al., 2018), which enables a business to see its products and/or service and wider ecosystem in greater detail.

Since data plays the key role in CE ecosystem's, digital technologies can enable ecosystem transition by including faster and more agile learning processes with iterative cycles of designing, prototyping, and gathering feedback, which are required for the complex task of redesigning key aspects of the economy. Increasing connectivity through IoT-enabled systems and smart devices can help firms to track and collect data in all the processes of supply chain. As well as improving asset utilization, reliability, and productivity for businesses through real-time data transformation which leads to less risk, improves operations of business as well as developing business. Remote monitoring and controlling capability of IoT helps firms to stay competitive internationally. Finally, BMI that uses AIoT to support the design of value propositions for CE model should be identified and implemented by businesses. Furthermore, to achieve the goals of CE, organizations should build their business ecosystem and make partners based on circular economy principles. A CE ecosystem is broader than normal business ecosystem, since all actors should share information, data and knowledge with partners and stakeholders and collaborate with them to deliver value for the whole ecosystem. In this regard, building partnership with different international partners who can support the circularity transition of the firm can accelerate the shift and increase competitive advantage of the organization and, factors in the increasing demand for more sustainable goods and services from industrialized countries.

CONCLUSIONS

In this chapter we have highlighted the importance of BMI for international business to transition towards a more CE, and the AIoT as an enabler of this. Adopting a CE based operating model requires that businesses initiate and develop disruptive technology and business models that are built on aspects such as longevity, renewability, reuse, repair, servitization, capacity sharing, and dematerialization (Batista, Tse and Soufani, 2018). In recent years global events, notable the COVID-19 crisis, has sped up the digital transformation of international business, and making it an imperative for businesses to reconfigure their operations to provide more digital and online capabilities (Sneader and Singhal, 2021). AIoT can provide technology which provides a platform for information sharing which can be a basis for many of these. For an internationally operating company this could mean closer co-operation with partners, renting e.g., capacity from other manufacturers' machines, manufacturing, and recycling on the spot (versus outsourcing manufacturing into a large-scale supplier) and production closer to the home again (i.e., reshoring) as the supply chain's linearity would be reversed. Producers could partner with other businesses that can help maintain, redistribute, or refurbish products, and this could create new potential in the ecosystem and/or value chain (Wieland and Durach, 2021). AIoT technology is an enabler for BMI which can change how global value chains look like in the future. Global might become local – but connectivity and data sharing might happen on the global scale with CE goals guiding the behavior of all stakeholders. We have discussed many of the positive implications that AIoT can have on international business and CE, but at the same time it is important to remain aware to emerging and potential negative consequences of the technology and so called "techlash," which are driven by privacy and trust concerns (EY, 2020). Time will tell how rapid the change will be, but it is evident that the megatrends discussed in this chapter will shape international business operations of the tomorrow.

REFERENCES

Aarikka-Stenroos, L., Ritala, P., & Thomas, L. D. W. (2021). Circular economy ecosystems: A typology, definitions, and implications. In S. Teerikangas, T. Onkila, K. Koistinen, & M. Mäkelä (Eds.), *Research Handbook of Sustainability Agency* (pp. 260–276). https://doi.org/10.4337/9781789906035.00024

Adner, R. (2016), "Ecosystem as Structure: An Actionable Construct for Strategy", *Journal of Management*, Vol. 43 No. 1, pp. 39–58. https://doi.org/10.1177/0149206316678451

Alcayaga, A., Wiener, M., and Hansen, E.G. (2019), "Towards a framework of smart-circular systems: An integrative literature review", *Journal of Cleaner Production*, Vol. 221, pp. 622–634. https://doi.org/10.1016/j.jclepro.2019.02.085

Antikainen, M. and Valkokari, K. (2018), "A Framework for Sustainable Circular Business Model Innovation", *Technology Innovation Management Review,* Vol. 6 No. 7, pp. 5–12. https://doi.org/10.1016/j.procir.2018.04.027

Batista, L., Bourlakis, M., Smart, P. and Maull, R. (2018), "In search of a circular supply chain archetype–a content-analysis-based literature review", *Production Planning and Control,* Taylor & Francis, Vol. 29 No. 6, pp. 438–451. https://doi.org/10.1080/09537287.2017.1343502

Bocken, N.M.P., Short, S.W., Rana, P. and Evans, S. (2014), "A literature and practice review to develop sustainable business model archetypes", *Journal of Cleaner Production*, Elsevier Ltd, Vol. 65, pp. 42–56. https://doi.org/10.1016/j.jclepro.2013.11.039

Boldrini, J.C. and Antheaume, N. (2021), "Designing and testing a new sustainable business model tool for multi-actor, multi-level, circular, and collaborative contexts", *Journal of Cleaner Production*, Elsevier Ltd, Vol. 309 No. 309. https://doi.org/10.1016/j.jclepro.2021.127209

Chesbrough, H. (2007), "Business model innovation: It's not just about technology anymore", *Strategy and Leadership,* Vol. 35 No. 6, pp. 12–17.

Denuwara, N., Maijala, J. and Hakovirta, M. (2019), "Sustainability benefits of RFID technology in the apparel industry", *Sustainability (Switzerland),* Vol. 11 No. 22, https://doi.org/10.3390/su11226477.

Ellen MacArthur Foundation. (2019), "Artificial intelligence and the circular economy - AI as a tool to accelerate the transition", available at: http://www.ellenmacarthurfoundation.org/publications. (accessed 31 August 2021)

EM Foundation. (2015), "Towards a Circular Economy: Business Rationale for an Accelerated Transition", *Greener Management International*, p. 20. (accessed 31 August 2021)

Evans, M. (2018), "IoT Will Have The Most Impact On Business In The Next Five Years, Survey Says", available at: https://www.forbes.com/sites/michelleevans1/2018/05/31/iot-will-have-the-most-impact-on-business-in-the-next-five-years-survey-says/?sh=3fc71915a3d1(accessed 31 August 2021)

EY. (2020), "Are your reframing your future or is the future reframing you? Understanding megatrends will help you see opportunities where others don't - Megatrends 2020 and Beyond", *EY,* available at: https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/megatrends/ey-megatrends-2020-report.pdf (accessed 31 August 2021)

Frishammar, J. and Parida, V. (2018), "Circular Business Model Transformation: A Roadmap for Incumbent Firms", *California Management Review,* Vol.61 No. 2, pp. 5-29. https://doi.org/https://doi.org/10.1177/0008125618811926

Geissdoerfer, M., Pieroni, M.P.P., Pigosso, D.C.A. and Soufani, K. (2020), "Circular business models: A review”, *Journal of Cleaner Production*, Vol. 277, 123741. https://doi.org/10.1016/j.jclepro.2020.123741

Geissdoerfer, M., Vladimirova, D. and Evans, S. (2018), “Sustainable business model innovation: A review”, *Journal of Cleaner Production*, Vol. 198, pp. 401–416. https://doi.org/10.1016/j.jclepro.2018.06.240

Ghoreishi, M. and Happonen, A. (2020), “New promises AI brings into circular economy accelerated product design: A review on supporting literature”, *E3S Web of Conferences*, Vol. 158, https://doi.org/10.1051/e3sconf/202015806002.

Haaker, T., Ly, P.T.M., Nguyen-Thanh, N. and Nguyen, H.T.H. (2021), “Business model innovation through the application of the Internet-of-Things: A comparative analysis”, *Journal of Business Research*, Vol. 126, pp. 126–136. https://doi.org/10.1016/j.jbusres.2020.12.034

He, J. and Ortiz, J. (2021), “Sustainable business modeling: The need for innovative design thinking”, *Journal of Cleaner Production*, Vol. 298. https://doi.org/10.1016/j.jclepro.2021.126751.

Hennart, J.-F. (1989), “Can the the new forms of investment substitute for the old forms? a transaction costs perspective”, *Journal of International Business Studies*, Vol. 20 No. 2, pp. 211–234.

Ingemarsdotter, E., Jamsin, E. and Balkenende, R. (2020), “Opportunities and challenges in IoT-enabled circular business model implementation – A case study”, *Resources, Conservation and Recycling*, Elsevier B.V., Vol. 162, p. 105047. https://doi.org/10.1016/j.resconrec.2020.105047

Jacobides, M.G., Cennamo, C. and Gawer, A. (2018), “Towards a theory of ecosystems”, *Strategic Management Journal*, Vol. 39 No. 8, pp. 2255–2276. https://doi.org/10.1002/smj.2904

Karakas, F. (2009), “Welcome to World 2.0: The new digital ecosystem”, *Journal of Business Strategy*, Vol. 30 No. 4, pp. 23–30. https://doi.org/10.1108/02756660910972622

Kirchherr, J., Reike, D. and Hekkert, M. (2017), “Conceptualizing the circular economy: An analysis of 114 definitions”, *Resources, Conservation and Recycling*, Vol. 127, pp. 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Kogut, B. and Zander, U. (1993), “Knowledge of the firm and the evolutionary theory of the munltinational corporation”, *Journal of International Business Studies*, Vol. 24, pp. 625–645. https://doi.org/10.1057/palgrave.jibs.8490248

Konietzko, J., Bocken, N. and Hultink, E.J. (2020), “Circular ecosystem innovation: An initial set of principles”, *Journal of Cleaner Production*, Vol. 253, p. 119942. https://doi.org/10.1016/j.jclepro.2019.119942

Kristoffersen, E., Blomsma, F., Mikalef, P. and Li, J. (2020), “The smart circular economy: A digital-enabled circular strategies framework for manufacturing companies”, *Journal of Business Research*, Vol. 120, pp. 241–261. https://doi.org/10.1016/j.jbusres.2020.07.044

Lewandowski, M. (2016), “Designing the business models for circular economy-towards the conceptual framework”, *Sustainability (Switzerland)*, Vol. 8 No. 1, pp. 1–28. https://doi.org/10.3390/su8010043

Lieder, M. and Rashid, A. (2016), “Towards circular economy implementation: A comprehensive review in context of manufacturing industry”, *Journal of Cleaner Production*, Elsevier Ltd, Vol. 115, pp. 36–51. https://doi.org/10.1016/j.jclepro.2015.12.042

Margaretta, J. (2002), “Why business model matter," *Harvard Business School Publishing Corporation*, Vol. 80 No. 5, pp. 86-92.

Massa, L. and Tucci, C.L. (2014), “Business Model Innovation”, *Oxford Handbooks Online,*

available at:https://doi.org/10.1093/oxfordhb/9780199694945.013.002.
McCarthy, J. (2007), “What Is Artificial Intelligence?”, *Stanford University Stanford, CA 94305*.
Merli, R., Preziosi, M. and Acampora, A. (2018), “How do scholars approach the circular economy? A systematic literature review”, *Journal of Cleaner Production*, Vol. 178, pp. 703–722. https://doi.org/10.1016/j.jclepro.2017.12.112
Metallo, C., Agrifoglio, R., Schiavone, F. and Mueller, J. (2018), “Technological Forecasting & Social Change Understanding business model in the Internet of Things industry”, *Technological Forecasting & Social Change*, No. February, pp. 0–1. https://doi.org/10.1016/j.techfore.2018.01.020
Miles, I., Saritas, O. and Sokolov, A. (2016), "Foresight for Science, Technology and Innovation," *Springer International Publishing*, Switzerland. https://doi.org/10.1007/978-3-319-32574-3
Moore, J.F. (1996), "The Death of Competition: Leadership and Strategy in the Age of Business Ecosystems," *WileyHarperBusines*s, Chichester New York NY.
Osterwalder, A. and Pigneur, Y. (2010), "Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers", *John Wiley & Sons*, Hoboken NJ.
Pialot, O., Millet, D. and Bisiaux, J. (2017), “‘Upgradable PSS’: Clarifying a new concept of sustainable consumption/production based on upgradablility”, *Journal of Cleaner Production*, Vol. 141, pp. 538–550. https://doi.org/10.1016/j.jclepro.2016.08.161
Pieroni, M. de P., McAloone, T. and Pigosso, D. (2019), “Business model innovation for circular economy: Integrating literature and practice into a conceptual process model”, *Proceedings of the International Conference on Engineering Design, ICED*, Vol. 2019, pp. 2517–2526. https://doi.org/10.1016/j.jclepro.2019.01.036
Porter, J. (2021), “IoT and the circular economy – TechNative”, available at: https://technative.io/iot-and-the-circular-economy/
Ramadoss, T.S., Alam, H. and Seeram, P.R. (2018), “Artificial Intelligence and Internet of Things enabled Circular economy”, The International Journal of Engineering and Sciences (IJES), Vol. 7 No. 9 pp. 55–63. https://doi.org/10.9790/1813-0709035563
Reike, D., Vermeulen, W.J.V. and Witjes, S. (2018), “The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options”, *Resources, Conservation and Recycling*, Vol. 135 No. February 2017, pp. 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027
SAS. (2019), “The Autonomous Grid in the Age of the Artificial Intelligence of Things”, *White Paper*, available at: https://www.sas.com/en/whitepapers/autonomous-grid-age-of-aiot-110207.html (accessed 31 August 2021)
SAS. (2020), “Title WHITE PAPER The Artificial Intelligence of Things From smart connected devices to artificially intelligent things, services and experiences ”, *White Paper*, available at: https://www.sas.com/en/whitepapers/artificial-intelligence-of-things-110060.html (accessed 31 August 2021)
SITRA. (2021), "The Winning Recipe For A Circular Economy What Can Inspiring Examples Show Us? The Winning Recipe for a Circular Economy", available at: www.sitra.fi. (accessed 31 August 2021)
Sneader, K. and Singhal, S. (2021), "The next Normal Arrives: Trends That Will Define 2021-and Beyond", *McKinsey & Company*. available at: https://www.mckinsey.com/featured-insights/leadership/the-next-normal-arrives-trends-that-will-define-2021-and-beyond
Talmar, M., Walrave, B., Podoynitsyna, K.S., Holmström, J. and Romme, A.G.L. (2018), “Mapping, analyzing and designing innovation ecosystems: The Ecosystem Pie Model”,

Long Range Planning, Elsevier, Vol. 53 No. 101850. https://doi.org/10.1016/j.lrp.2018.09.002

Teece, D.J. (2010), "Business models, business strategy and innovation", *Long Range Planning*, Vol. 43 No. 2–3, pp. 172–194. https://doi.org/10.1016/j.lrp.2009.07.003

Velocity Global. (2018), "How the Internet of Things will Impact Global Business | Velocity Global", available at: https://velocityglobal.com/blog/industry-news-how-the-internet-of-things-will-impact-global-business/ (accessed 31 August 2021).

Whitmore, A., Agarwal, A. and Da Xu, L. (2015), "The Internet of Things—A survey of topics and trends", *Information Systems Frontiers*, Vol. 17 No. 2, pp. 261–274. https://doi.org/10.1007/s10796-014-9489-2

Wieland, A. and Durach, C.F. (2021), "Two perspectives on supply chain resilience", *Journal of Business Logistics*, Vol. 42 No. 3, pp. 315–322. https://doi.org/10.1111/JBL.12271

Wirtz, B.W., Pistoia, A., Ullrich, S. and Göttel, V. (2016), "Business Models: Origin, Development and Future Research Perspectives", *Long Range Planning*, Vol. 49 No. 1, pp. 36–54. https://doi.org/10.1016/j.lrp.2015.04.001.

World Economic Forum. (2019), *Harnessing the Fourth Industrial Revolution for the Circular Economy Consumer Electronics and Plastics Packaging, The Platform for Accelerating the Circular Economy (PACE)*, available at: www.weforum.org. (accessed 31 August 2021)