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Konietzko, Jan; Bocken, Nancy; Hultink, Erik Jan

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23

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Jan Konietzko, Nancy Bocken and Erik Jan Hultink

Introduction

Online platforms have become essential for many people. They organise data streams, economic interactions and social exchanges between users

J. Konietzko (✉)
Departments of Design Engineering and Product Innovation Management, Delft University of Technology, Delft, The Netherlands
e-mail: j.c.konietzko@tudelft.nl

N. Bocken
Lund University IIIEE, Lund, Sweden
e-mail: nancy.bocken@iiiee.lu.se

N. Bocken · E. J. Hultink
Department of Product Innovation Management, Delft University of Technology, Delft, The Netherlands
e-mail: h.j.hultink@tudelft.nl

N. Bocken
Lappeenranta University of Technology, Lappeenranta, Finland

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(van Dijck et al. 2018). The platform-based companies Google, Apple, Facebook and Amazon have aggregated power at unprecedented speed and scale: their combined market capitalisation grew from $430 billion in 2010 (roughly the GDP of Poland) to more than $2300 billion in 2017 (roughly the GDP of India, the seventh largest economy in the world[1]) (Galloway 2017). These four 'GAFA platforms' sit at the core of what is becoming a platform society, in which a global, corporate infrastructure uses data and algorithms to organise social and economic interactions (van Dijck et al. 2018). From a business perspective, online platforms are seen as multi-sided marketplaces that can enable people to efficiently exchange a large variety of physical products (e.g. used cars or furniture), build communities around specific product categories (e.g. handmade design), match service firms with users (e.g. local food delivery), exchange online services (e.g. language tutoring) and engage in peer-to-peer exchange of offline services (e.g. ridesharing) (Täuscher and Laudien 2017).

The main question for firms who launch and manage online platforms is how they enable others to create value on their platforms (Bonchek and Choudary 2013). Interactions and data have become key assets for this. The ability to collect and leverage data from interactions is driving competitive advantage in the platform society (Van Alstyne et al. 2016). The more sides, the more interactions; the more interactions, the more opportunities to collect and analyse data to increase platform value. This is called 'network effects', whereby every additional user on the platform increases the value of the overall platform (Gawer and Cusumano 2014). Some have claimed that understanding this new form of competitive advantage has become key for firm survival (Van Alstyne et al. 2016).

Recently, online platforms have been named an enabler for a circular economy (e.g. Lewandowski 2016). The goal of a circular economy is to radically increase resource efficiency on a systems level by maximising the value of products, components and material, while minimising resource inputs, waste, emission and energy leakage (EMF 2015; Geissdoerfer et al. 2017). This can be done by narrowing (use less), slowing (use longer) and closing (use again) resource loops. Narrowing refers to maximising

efficiency and reducing material intensity of products, components and material; slowing seeks to maximise the value of products and components within the economic system by reusing, repairing, maintaining, refurbishing, remanufacturing and sharing them; closing means the recycling of material at the end of product and component lives. The circular economy can be described as a sub-concept of sustainable innovation. It can potentially speed up the adoption of more resource-efficient ways of doing business, as it is more narrowly defined than the broader field of sustainable innovation (Geissdoerfer et al. 2017). Some have claimed that online platforms have contributed to implementing a circular economy by allowing people and organisations to share access to underused physical goods and thereby reduce their excess capacity and slow resource loops (EMF 2015). Google, one of the biggest online platforms, has partnered with the Ellen MacArthur Foundation to digitally enable a circular economy (EMF 2017).

So far, literature has mostly addressed the environmental sustainability of online platforms in the so-called sharing economy. Their potential impact on the environment appears to be mixed: sharing economy platforms can both contribute to sustainability (e.g. by reducing excess capacity) and inhibit it (e.g. by increased energy use of growing data centres) (Lelah et al. 2011; Frenken and Schor 2017). We extend this perspective and investigate how online platforms can enable a more sustainable and circular economy. A review of relevant literature reveals three roles online platforms can play in this: they can serve to (1) market, (2) operate and (3) co-create products, components and material. In the next section, we describe these roles and use practice examples to highlight their potential in enabling a more circular economy. We then provide a recommendations for how practitioners can experiment with online platforms to advance their digital transition towards a circular economy.

Online Platforms and the Circular Economy

Online platforms can serve as a means to market, operate, and co-create products, components and material in order to narrow, slow and close resource loops in a circular economy. Table 23.1 shows how we have

Table 23.1 The roles of online platforms, how literature describes them and their key potential for a circular economy

Role	Literature description	Key potential for a circular economy
Market	Coordinate economic interactions between groups of platform actors (Chasin et al. 2017) Handle messages, execute transactions, provide market overviews and price transparency, support customer decisions, share information, support product innovation (Alt and Klein 2011) Crowdfunding platforms (a specific type of electronic marketplace): a promising source of sustainable venture capital (Bocken 2015) Reduce transaction cost, minimise excess capacity (sharing economy) (Frenken and Schor 2017) Interactions and data as key assets for creating value and driving competitive advantage (Van Alstyne et al. 2016) Network effects as a strategic goal (Gawer and Cusumano 2014)	Share access to existing products Resell and trade used products and waste material
Operate	Enablers of collaborative product-service systems and servitisation (Evans et al. 2007; Manzini and Vezzoli 2003; Baines and Lightfoot 2013; Cenamor et al. 2015) Drive customisation and efficiency for servitised offerings (Cenamor et al. 2015) The gateways to providing, accessing and maintaining physical assets to inform maintenance and repair (Morlet et al. 2016)	Collaborate with others to jointly provide product-service systems Collect data to maintain and repair

(continued)

Table 23.1 (continued)

Role	Literature description	Key potential for a circular economy
Co-create	Enablers of citizen and community participation, empowerment, collective action, inclusive co-creation of internet-of-things applications and open innovation, with an emphasis on smart cities (Lee et al. 2014; Stratigea et al. 2015; Hribernik et al. 2011; Anttiroiko et al. 2014) A means for information exchange, knowledge creation, feedback, debate, learning, innovation and social networking (Medema et al. 2014), encourage partnerships and co-creation of sets of platform elements (Evans et al. 2007)	Repair, (re-)design, own, manufacture Share knowledge and information Debate and learn

allocated the relevant literature[2] within these three roles, and what their key potential is in enabling a more circular economy. In the following sections, we describe this in more detail and provide examples for how these three roles have been put into practice.

Market

Online platforms serve as electronic markets (Alt and Klein 2011). They coordinate exchange between groups of platform actors (Chasin et al. 2017), by handling their communication, providing market overviews and price transparency, supporting customer decisions and sharing relevant information (Alt and Klein 2011). Moreover, crowdfunding platforms have been described as promising sources of sustainable venture capital (Bocken 2015).

As electronic markets in a circular economy, online platforms can potentially help slow resource loops by enabling access to existing products. This is often referred to as the sharing economy. Examples include Peerby (enables temporary access to private goods like drills or bicycles) or Airbnb (enables temporary access to private homes). Reduced transaction cost has enabled people and organisations to share access to their products and thereby reduce and monetise their excess capacity (Frenken and Schor 2017). For example, three empty seats in a car while driving on the road equal to an excess capacity of 75%. If a person makes these seats available, then he or she is decreasing and/or monetising excess capacity, enabled by reduced transaction cost. This form of 'sharing' as an economic transaction has become a recognised business action for implementing a circular economy (EMF 2015). The idea is that excess capacity might help to slow resource flows because using existing products instead of buying new ones can reduce the need for new products and associated resources.

Even though many sharing economy platforms have claimed environmental benefits, they also seem to inhibit sustainability (Frenken and Schor 2017). For example, they have expanded trade volumes and created additional purchasing power beyond reducing the excess capacity of existing products (ibid.). This has led to indirect rebounds that can

offset potential benefits (Chitnis et al. 2013). Next to indirect rebounds, power-consuming data centres and the environmental impacts of used hardware may lead to further direct rebounds (Boons and Bocken 2017). Especially, sharing economy platforms tend to use and sustain existing, potentially unsustainable infrastructure. The car-sharing platform Zipcar, for example, runs mostly on fossil-fuel-based vehicles. Airbnb provides access to houses that can consume high levels of energy. Due to their dependence on mobile and wireless infrastructure, online platforms have also contributed to the overall environmental impacts of mobile communication (ibid.).

In general, whether online platforms as markets contribute to environmental sustainability is a matter of deliberate design choices (Tukker 2015; Mont 2002; Bocken 2017). This can be seen in examples that leverage online platforms as markets for used products and waste material. The online platform Fairmondo, for example, promotes used, more sustainable and long-lasting products and charges a lower commission for providers of fair and sustainable products. The platform Kleiderkreisel enables its users to resell used clothing. The Materials Marketplace facilitates the reuse of company-to-company industrial waste. These platforms thus make deliberate choices to enable the slowing and closing of resource loops via online platforms.

Operate

Online platforms can serve to operate product-service systems (Alt and Klein 2011; Manzini and Vezzoli 2003; Cenamor et al. 2015). Product-service systems refer to a combination of products and services to create customer value (Boehm and Thomas 2013). Products can be provided on three service levels: basic (e.g. product sale plus warranty), intermediate (product sale plus maintenance, repair or training services) and advanced (no product sale, instead a focus on outcomes and solutions) (Baines and Lightfoot 2013). Intermediate services often aim at extending the lifetimes of products (e.g. through maintenance contracts). Advanced services, in which firms retain ownership over their products, incentivise firms to invest in long-lasting products that are easy to maintain and repair. They can therefore enable a more circular economy (Tukker 2015).

Online platforms can be used to operate product-service systems by collecting data on the use, location and condition of deployed products. This can help to slow resource loops by optimising their use and flagging the need for maintaining, repairing, refurbishing and remanufacturing them (Morlet et al. 2016). A recent article has described how platforms can help optimise service offerings (Cenamor et al. 2015). The back end (the non-user facing side) of a platform can orchestrate diverse offerings, while the front end (the user-facing side) can customise them for individual use cases (ibid.). Online platforms can thus be seen as the gateways to providing, accessing and maintaining physical assets in flexible ways (Morlet et al. 2016). In theory, everything can be connected to collect, analyse and use data to optimise the use of products, components and material.

This can potentially involve many different actors across sectors who become part of complex service ecosystems. An example of a multi-sided online platform is the company Instacart, which delivers groceries from local stores to people's doorsteps (Stanley 2017). It coordinates interactions between four sides: customers who receive the delivered groceries, shoppers who get contracted to shop and deliver them, stores who provide the inventory of products and products that get searched, picked and delivered. The company's director of data science explains: '*it turns out that the four-sided marketplace is a lot more complex than just a two-sided marketplace [and] every pair of interactions is a significant opportunity and a significant source of data, a significant potential place to influence and affect things*' (Stanley 2017, paragraph 28).

This ability to influence and affect things can be leveraged to collect and analyse data to optimise the use and exchange of products, components and material in a system to narrow, slow and close resource loops. The German project Adaptive City Mobility, for example, seeks to provide a zero-emissions e-mobility system for cities via a common online platform. It is designed to coordinate interaction between at least five entities: local fleet operators (e.g. taxi companies) who operate flexible pools of lightweight, electric vehicles, end users who can access the same vehicles, service providers who maintain and repair the vehicles, local energy providers who can sell their renewable energy through the battery management and exchange system of the vehicles, and local service

providers (e.g. restaurants) who can promote their offerings through ads that are shown on the vehicle displays. The software orchestrates this complex service ecosystem through careful, collaborative design.

Co-create

Lastly, online platforms can empower people to co-create products and services (Evans et al. 2007). This includes the co-creation and exchange of information and knowledge, and the opportunity to debate and learn (Medema et al. 2014). Literature has emphasised this mostly in the context of smart cities (Lee et al. 2014; Stratigea et al. 2015; Hribernik et al. 2011; Anttiroiko et al. 2014).

Most online platforms that enable the co-creation of products and services for a circular economy are part of the so-called open source movement (Bakker et al. 2018). The movement proposes that individuals want or need to participate in creating a circular economy. Repair cafes, maker spaces, sharing economy platforms and distributed manufacturing are current manifestations of this interpretation (ibid.). Popular examples of online platforms that enable people to co-create the circular economy include iFixit, which provides crowd-sourced repair kits for products, as well as the Open Source Circular Economy Days, a platform that allows people to explore and co-create a circular economy through open source methods and solutions.

Further examples of how people and firms can co-create on online platforms include: Mobotiq, a blockchain-based, clean mobility startup that has built an online platform on which individuals can become investors, designers, manufacturers and operators. The mobility company Local Motors has set out to let thousands of people co-create vehicle designs that are adaptable, open, customisable and repairable. The cooperative car-sharing platform Modo has fostered co-creation through shared ownership, and therefore shared care, of physical assets. Finally, the ride-sharing platform LaZooz, also focused on using physical resources (in this case, cars) more effectively, has offered a decentralised peer-to-peer ride-sharing service with its own token system for unlimited ways of co-creating value on the platform.

Despite these examples, the overall level of co-creation via online platforms has been decreasing over the past years (it should, however, be noted that not all online platforms have been initiated with a 'co-creative intent'). Nevertheless, van Dijck et al. have argued that, rather than enabling new forms of co-creation, sharing economy platforms have become a mere facilitator of economic transaction (2018). In addition, a recent review of online platforms has found no evidence that online platforms contribute to a decentralisation or democratisation of innovation processes (Dolata 2017). To the contrary, concentrated corporate power clusters have dominated the platform society in terms of traffic and market value. The online platforms that form the core of these clusters have exceptional stock market values and considerable liquidity, which they use to undertake high investments and major acquisitions on a regular basis (ibid.). This indicates an overall decline of the use of the co-creation potential of online platforms.

Also here it is important to realise that using this potential role is a design choice. The above examples show the many possibilities: people and organisations can collaborate to share knowledge and information, repair, (re)design, own and manufacture products, components and material through online platforms. Leach et al. have stressed the importance of this in light of sustainable development goals: '*[…] delivering on [sustainable development goals] requires a radically new approach to innovation, one that gives far greater recognition and power to grassroots actors and processes, involving them within an inclusive, multi-scale innovation politics*' (2012: 1). Fostering co-creation on online platforms can thus be seen as an important mandate for sustainable development. The above examples show initial ways of how this can be done.

Recommendations for Practitioners

The highlighted roles of online platforms can serve as a playground for firms to come up with new ideas for transitioning towards a circular economy. Figure 23.1 provides an overview of the three roles.

Some example questions to support ideation of how online platforms can be used to market, operate and co-create products, components and material include:

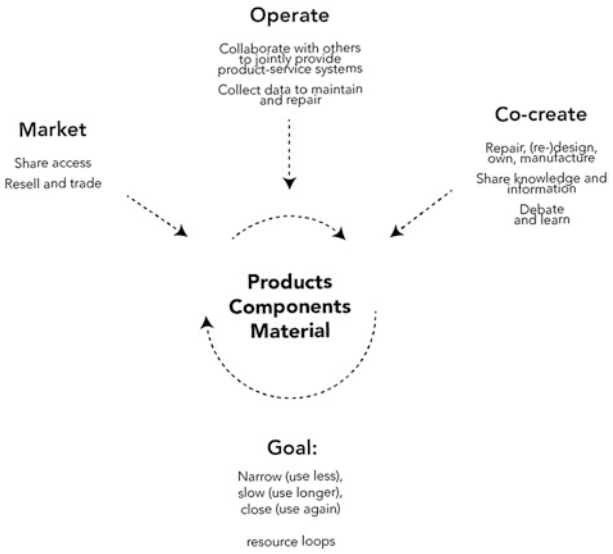

Fig. 23.1 The roles of online platforms in enabling a circular economy: market, operate and co-create products, components and material

- Market:
  - How can a firm use existing online platforms to reduce the excess capacity of their products? How radical would this be compared to the current way of doing business? How can this become a viable possibility, e.g. by collaborating with online platforms?
  - Does a firm have waste materials that can potentially be traded via online platforms? Can waste materials that are traded on online platforms be used as product inputs?
- Operate:
  - How can firms connect to existing online platforms to offer and evolve their products and services as part of larger product-service systems? What kinds of collaborations would be needed for that?
  - How can firms collaborate with others to co-create new online platforms that support the circular economy?

- Co-create:
  - How can firms use online platforms as a tool to co-create circular products, components and materials, as well as services, with outside parties?
  - How can firms leverage online platforms to obtain and share information and knowledge about their products in support of the circular economy?

New ideas are usually full of assumptions about how and whether they are desirable, feasible and viable (Osterwalder et al. 2014). A next step would then be to formulate, prioritise and test these assumptions. For example, finding a way of reselling already-sold and used products via online platforms assumes that this aligns with the existing firm philosophy, that a particular set of customers desire them, that it is feasible to do this in terms of available and accessible skills and resources, or that it is viable in terms of costs and benefits. Conducting business experiments to test these kinds of assumptions can help make first steps to start leveraging the roles of online platforms for narrowing, slowing and closing resource loops (Bocken et al. 2018). This requires an open mindset: only by allowing new ideas to emerge, and by testing their assumptions will firms 'fail forward' (Ries 2017) and learn how they can transition towards a digital, circular economy.

Conclusion

This chapter has highlighted three roles online platforms can play in enabling a circular economy. First, as markets, they can reduce excess capacity and enable the reselling of used products, components and material. Second, in their role as operators of product-service systems, they can coordinate complex service ecosystems and inform maintenance and repair needs. Third, their role in fostering co-creation opens new ways for collaborating and participating in different kinds of activities. Examples have shown how these roles have been leveraged in practice. With this work, we hope to inform practitioners about the

importance and potential of online platforms and to inspire them to think about this potential in their own contexts. From a theoretical perspective, we contribute a framework for the roles of online platforms in enabling a circular economy. The three roles are by no means exhaustive. Ample research is still needed to better understand how online platforms can be used to enable a circular economy. This also applies to sustainable innovation more generally, as this chapter has focused on the more narrow aspects of product, component and material flows. It is therefore crucial to pay equal attention in the future to their role in addressing social issues like income equality and social cohesion.

Notes

1. We acknowledge that this is a bit like comparing apples and oranges. But it indicates how rapidly and at what scale platforms have been growing.
2. We used literature from a targeted search in the most cited articles on sustainable innovation. Even though the focus of this chapter is on the circular economy, we used literature on sustainable innovation because the former has emerged from the latter and can therefore be further informed by it. We used a variety of search strings (e.g.: "sustainable innovation" AND platform* (results: 35); or: platform* AND sustainability AND innovation (results: 294); or: 'sustainability AND digital* AND platform*' (results: 181) or 'sharing economy AND sustainability' (results: 58) for titles, keywords and abstracts in the academic database SCOPUS. We filtered articles that: (1) clearly refer to online platforms as defined in this article, (2) are no older than ten years and (3) that have been cited more than 10 times or have been published within the last two years. We ended up with 15 articles for review.

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