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Eco-innovation and Circular Business Models as drivers for a circular economy

Eco-innovación y modelos de negocio circulares como facilitadores de una economía circular

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Abstract

Eco-innovation is defined as any directed/oriented innovation aiming at reducing environmental impacts. Eco-innovation is not only a technology change; it also embraces organisational, social and system innovations. This systemic and complex thinking is necessary to understand the role of eco-innovation as an enabler of Circular Economy (CE). Circular Economy appears as a promising approach towards a sustainable transition from the linear socioeconomic paradigm. The objective of the Circular Economy is to maintain and to share value along the time. Eco-innovation for Circular Economy can be of technological and non-technological character. Indeed, it is acknowledged that CE needs to address important challenges regarding business models and socio-institutional frameworks, while technological change may not be necessarily radical. In order to pave the way to Circular Economy through eco-innovation, business models are considered a key driver. The business model is seen as a holistic approach towards the way of doing business. From the eco-innovation perspective, a business model needs to add ecological and social value to the value proposal and changing the producer and the consumer practices. In particular, eco-innovations with the potential to enable the transition to a resource-efficient circular economy model include efforts to change dominant business models (from new product and service design to reconfigured value chains, new/short supply chains), transform the way citizens interact with products and services (ownership, leasing, sharing, repairing, reducing, remanufacturing, etc.) and develop improved systems for delivering value (green mobility, smart energy systems, short supply chains, etc.).

JEL code: O30; O33; O39; Q01; Q55

Keywords: Eco-innovation; Circular economy; Sustainability; Circular economy business models.

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Resumen

La eco-innovación se define como cualquier innovación dirigida/orientada a la reducción del impacto medioambiental. La eco-innovación no es sólo un cambio tecnológico, sino que también abarca las innovaciones organizativas, sociales y sistémicas. El pensamiento sistémico y complejo es necesario para entender el papel de la eco-innovación como facilitador de la Economía Circular (EC). La Economía Circular se presenta como un enfoque prometedor hacia una transición sostenible desde el paradigma socioeconómico lineal. El objetivo de la Economía Circular es mantener y compartir valor a lo largo del tiempo. La eco-innovación para la Economía Circular puede ser de carácter tecnológico y no tecnológico. De hecho, se reconoce que la EC necesita abordar retos importantes en relación con los modelos de negocio y los marcos socio-institucionales, mientras que el cambio tecnológico puede no ser necesariamente radical. Con el fin de allanar el camino hacia la Economía Circular a través de la eco-innovación, los modelos de negocio se consideran un motor clave. El modelo de negocio representa un enfoque holístico hacia la forma de hacer negocios de una organización. Desde la perspectiva de la eco-innovación, un modelo de negocio necesita añadir valor ecológico y social a la propuesta de valor y cambiar las prácticas del productor y del consumidor. En particular, las eco-innovaciones que pueden permitir la transición a un modelo de Economía Circular eficiente en el uso de los recursos incluyen esfuerzos para cambiar los modelos de negocio dominantes (desde el diseño de nuevos productos y servicios hasta la reconfiguración de las cadenas de valor, cadenas de suministro nuevas/cortas), transformar la forma en que los ciudadanos interactúan con los productos y servicios (propiedad, arrendamiento, reparto, reparación, reducción, remanufactura, etc.) y desarrollar sistemas mejorados para la creación de valor (movilidad ecológica, sistemas de energía inteligente, cadenas cortas de valor, etc.).

Código JEL: O30; O33; O39; Q01; Q55
Palabras clave: Eco-innovación; Economía Circular; Sostenibilidad; Modelos de Negocio para la Economía Circular.

Introduction

The CE concept is appealing for a wide range of academics, managers and policy makers because it is viewed as a useful operationalization of the broader and slippery concept of sustainable development. The discussion about the role of eco-innovation in relation to Circular Economy needs to be framed in the context of the capitalist system. Capitalism is a system driven by the search of profits and the continuous accumulation of capital. Innovation plays a key role in this ongoing process of expansion. The acknowledgement of the serious ecological crisis that affects Capitalism has resulted in different views regarding the possible solutions. Some authors argue that firms may implement several strategies to drive Capitalism towards a new environmentally-friendly stage (Hawken et al., 2013). On the contrary, other authors understand that the ecological crisis is a systemic crisis and point out the need to substitute for the whole capitalist system (Foster et al. 2011).

Ecological modernisation argues that economy and ecology – or capitalism and the environment – can be effectively and efficiently combined to produce a form of sustainability, one that does not fundamentally disrupt the status quo in terms of power, norms and politics.

Among the optimists, Hawken & Lovins (2013), identify four strategies to boost the system change: i) to search for a radical increase of resources productivity; ii) biomimicry and industrial ecology; iii) servicizing; and iv) investments in natural capital regeneration.

For Speth (2008) trusting in technological change is not enough to address the serious environmental problems that already exist. Technological progress may help to correct some environmental harm and achieve some increase in resource productivity but these only decrease the speed of destruction.

Anyway, the transition towards a new economic system cannot happen easily and fast. In the meanwhile, different innovation strategies may support the necessary changes. Altvater (2012) identifies three different revolutions towards a new renewable energy-based society: i) the efficiency revolution, which extends Capitalism and the fossil regime; ii) the sufficiency revolution, based on the use value rather than on exchange value; and iii) the consistency revolution, where a new alliance among economy, ecology, society, production, consumption and nature is achieved. The latter implies to set limits to production and consumption, hence, to block the coherence of capitalist society, fossil energies and the industrial rationale that dominates the world.

The Circular Economy (CE) is a family of specific proposals for a new productive paradigm focusing on minimising the usage of material resources, energy and reducing waste.

The aim of this paper is to discuss the role of eco-innovation and business models in the transition towards a Circular Economy, following the relevant literature on these three topics. To tackle this objective, the paper methodology is based on the review of important selected papers and reports, dealing with the key definitions. The paper tries to discuss the role of eco-innovation and business models as enablers for the system shift, keeping in mind that other important factors, namely institutions and policies, may be of utmost importance.

The remainder of the paper is organised as follows: the first section goes through the definition, characteristics and principles of the Circular Economy. In the second section, the literature on eco-innovation is overviewed and finally, the role of business models is analysed as a catalyser of eco-innovations and as a driver of systemic change towards Circular Economy. Some conclusions and final reflections are provided in the last section.

Circular economy: towards a new paradigm

The ultimate goal of promoting CE is the decoupling of environmental pressure from economic growth and well-being. The specific objective of the Circular Economy is to reduce resource consumption, energy and waste by a perpetual returning of used resources into the economy. All resources incorporated to the economic cycle have to be managed as permanent renewable resources.

A popular concept of Circular Economy has being provided by the Ellen MacArthur Foundation: “an industrial economy that is restorative by intention; aims to rely on renewable energy; minimises, tracks, and eliminates the use of toxic chemicals; and eradicates waste through careful design” (Ellen MacArthur Foundation 2013, p. 22). Anyway, In spite of the long way of the background ideas we are living the boiling point of the CE paradigm. A recent literature review has gathered 114 different CE definitions (Kirchherr et al., 2017). Their findings indicate that “the circular economy is most frequently depicted as a combination of reduce, reuse and recycle activities” (Kirchherr et al., 2017, 22); surprisingly, they find few explicit linkages of the CE concept to sustainable development and an emphasis on a systemic shift less frequent than expected.

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The shift towards Circular Economy involves a systemic and radical change. The linear socio-economic paradigm of production and consumption, based on "take, make and dispose", needs to be radically transformed in order to fulfil the objectives of the Circular Economy, namely, eliminating waste and relying on renewable energies.

Circular Economy substitutes preservation value for added value and utilisation value for residual value, since it focuses on stock optimization (Stahel, 2013). Basically, Circular Economy requires decoupling economic growth from resource extraction and waste generation.

Stahel (2013) states that Circular Economy focus on managing existent stock is based on three different loops (Figure 1): i) reuse and resale of goods; ii) product life extension activities; and iii) recycling of molecules (secondary resources).

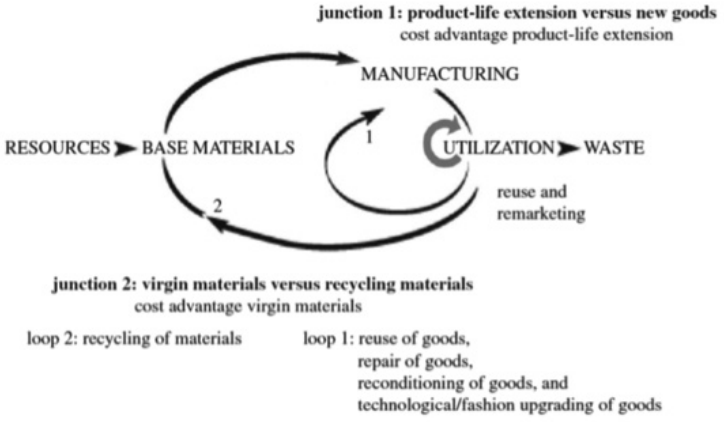

Figure 1. The main loops of a circular economy. Source: Stahel (2013)

The Circular Economy depends on five principles according to this view (Stahel, 2013):

1) The shorter the loop the more profitable and efficient in resources use. That means that there is a hierarchy regarding the circularity of goods: from reusing, repairing, re-manufacturing to recycling.

Moreover, the geographical dimension is important in order to avoid or reduce packaging and transportation as well as transaction costs.

2) Loops have no beginning and no end. In opposition to creating added value, in the Circular Economy the idea is to preserve value, quality and performance of goods along the time, through an adequate management of the stock.

3) Increasing the efficiency of stock management, which means a decreasing speed of the resources flow.

4) The retention of ownership is cost-efficient: reusing, repairing and remanufacturing activities save transaction costs.

5) New functioning markets:

- For life extension services of goods;

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- For lower costs, regarding the quality and age of goods;
- For life extension services of manufacture capital;
- For reutilization and resale of mobile investment goods and buildings;
- For consumer used goods;
- For reselling used goods and components

Thus, many authors argue that the Circular Economy contributes to Sustainable Development (de Jesus and Mendonça, 2018; Geissdoerfer et al., 2017). However, it cannot be conceived as a tool for growth-oriented economic systems. In this type of economy, efficiency is no longer the "winning card" and the rebound effect and market competition are likely to diminish the potential benefits of increased efficiency (Ghisellini et al., 2014).

The shift towards Circular Economy requires significant changes in production and consumption systems. Thus, innovation efforts are necessary, including technological, organizational and system innovation. However, the role of eco-innovation must be carefully examined (de Jesus et al., 2018).

Some of the apparently positive sustainable activities have negative environmental impacts (Murray et al., 2015). For instance, green fuel does not always take into account the environmental consequences of growing fuel plants; some green technologies rely upon rare earth metals; some long-lasting materials are very difficult to recycle. The authors criticise the exotic chemistry and prolonged servicing and replacement and suggest to use, instead, the appropriate technology (Schumacher, 1973), wherein smaller scale, locally adaptive solutions have less environmental impact than large scale global solutions. "The dependence upon technology for environmental progress risks privileging it over nature in the sustainable tripartite bottom line" (Murray et al., 2015). Anyway, the main issue is not the technology itself but the competitive pressure of established business models, the market power of big companies and its global value chains. "CE-type high value product reuse, remanufacturing and refurbishment, and not least the sharing economy, will have to compete with these cultures, routines and management models. The economics and business logic of path dependency may prevent many of the suggested CE innovations from penetrating the markets" (Korhonen et al, 2018, 44).

Eco-innovation: scope and limitations

The concept of eco-innovation has been used for a relatively long time and it has been defined in several ways (Pereira, 2016). The concept was probably used first in the mid-90s although pollution control innovation, pollution control technologies or environmental innovation were used previously and also refer to similar (technological) issues.

Under the Sixth Framework Programme of the European Commission two projects on eco-innovation were carried out in order to identify drivers and barriers, as well as indicators to

measure it. These documents offered definitions of eco-innovation that broadened the scope beyond environmental technologies.

Based on the definition of innovation of the Oslo Manual (OECD, 2005), the MEI Project suggested: "Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives" (Kemp and Pearson 2007, p. 7). This definition is complex in the sense that it requires specific knowledge about the environmental impacts of innovations and alternatives to it from the perspective of life cycle.

The Ecodrive Project (CML et al., 2008) defined eco-innovation restrictively as a subclass of innovation where economic and environmental performances of society are improved at the same time. From this point of view eco-innovation is specifically the one which is able to meet a double gain, to provide a win-win situation. This definition is in line with Porter's view of stricter environmental regulation as a way to improve business competitiveness (Porter and van der Linde, 1995).

Focusing on economic benefits, Andersen (2008) describes eco-innovations as "innovations which are able to attract green rents on the market". Once again, the double gain is emphasized, identifying eco-innovation with an opportunity to make profit through caring the environment.

Carrillo-Hermosilla et al (2009, p. 8) define eco-innovation simply as "an innovation that improves environmental performance" although the authors also add that "economic and social impacts play a crucial role in its development and application and hence determine its diffusion path and contribution to competitiveness and overall sustainability".

For the Eco-innovation Observatory, "eco-innovation is any innovation that reduces the use of natural resources and decreases the release of harmful substances across the whole lifecycle" (EIO, 2011).

There are some differences among the definitions: some of them see eco-innovation as a new way to improve business competitiveness by addressing environmental challenges; on the contrary, some others emphasise the environmental objective as the key defining aspect. This difference is not trivial. As stated by Saviotti (2005) environmental improvement can only be achieved by directing specific resources towards that goal, and not as the unintended result of investing with other objectives. This view is particularly relevant because rebound effects due to the growing diffusion of clean technologies or the increase of diversity (eco-innovative products) must be taken into account when assessing the environmental impact of new technologies. Additionally, it is known that in some Western countries there is a growing trend towards 'green consumerism'; however, buying environmentally-friendly products is not synonymous with reducing environmental impacts due to resource consumption. An increasing level of consumption offsets the possible effects of buying green (EIO, 2013).

Typology

According to the different range of definitions, several typologies of eco-innovation have also been proposed. For instance, the MEI Project distinguishes between environmental technologies, organizational innovations (introduction of organizational methods and management systems for dealing with environmental issues in production and products), product

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and service innovation (new or environmentally improved products and environmentally beneficial services) and green system innovations (see table 1 for a finer classification).

Table 1

Typology of eco-innovation

Environmental technologies	Pollution control technologies including waste water treatment technologies. Cleaning technologies that treat pollution released into the environment; Cleaner process technologies: new manufacturing processes that are less polluting and/or more resource efficient than relevant alternatives; Waste management equipment; Environmental monitoring and instrumentation; Green energy technologies; Water supply; Noise and vibration control.
Organizational innovation	Pollution prevention schemes: aimed at prevention of pollution through input substitution, more efficient operation of processes and small changes to production plants (avoiding or stopping leakages and the like); Environmental management and auditing systems: formal systems of environmental management involving measurement, reporting and responsibilities for dealing with issues of material use, energy, water and waste (EMAS and ISO 14001 are examples); Chain management: cooperation between companies so as to close material loops and to avoid environmental damage across the value chain (from cradle to grave).
Product and service innovation offering environmental benefits	New or environmentally improved material products (goods) including eco-houses and buildings; Green financial products (such as eco-leases or climate mortgages); Environmental services: solid and hazardous waste management, water and waste water management, environmental consulting, testing and engineering, other testing and analytical services; Services that are less pollution and resource intensive (car sharing is an example).
Green system innovations	Alternative systems of production and consumption that are more environmentally benign than existing systems: biological agriculture and a renewables-based energy system are examples.

Source: Kemp and Pearson (2007)

From another point of view, the OECD (2009) defines an eco-innovation typology on the basis of three axes: targets, mechanisms and impacts (Figure 2):

- The target is the basic focus of eco-innovation. It may refer to products (goods and services), processes, marketing methods, organizations or institutions.

- The mechanism refers to the method by which the change in the eco-innovation target takes place or is introduced. The strategies identified are modification, redesign, alternatives or creation.

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• Finally, the impact represents the innovation effect on environmental conditions and it depends on the combination of the innovation's target and mechanism. The change can vary from incremental as far as to the complete elimination of environmental harm. More specifically, innovation by its degree of impact is defined in this way (OECD, 2012):

-Incremental innovation aims at modifying and improving existing technologies or processes to raise efficiency of resource and energy use, without fundamentally changing the underlying core technologies;

-Disruptive innovation changes how things are done or specific functions are fulfilled, without necessarily changing the underlying technological regime itself.

-Radical innovation involves a shift in the technological regime of an economy and can lead to changes in the economy's enabling technologies.

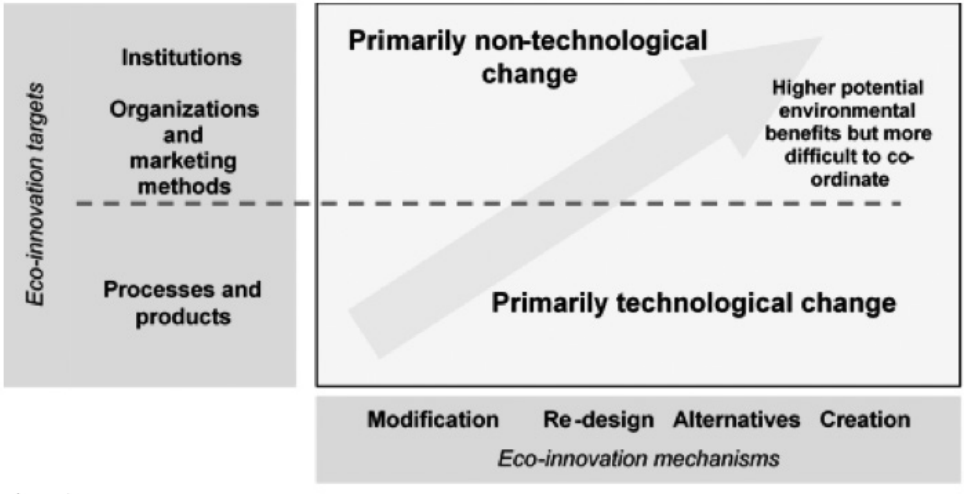

Figure 2. Typology of eco-innovation. Source: OECD (2009)

So far eco-innovation can be technological and non-technological, including organizational, social and institutional innovation (Rennings, 2000).

A slightly different typology is offered by Andersen (2008) according to the role eco-innovation plays in the market:

• Add-on eco-innovations. They refer to goods and services aimed at the use side (cleaning, recycling, measuring, monitoring, transportation) and at the source (extraction and supply of resources and energy). Those innovations are developed by the so-called environmental industry and they are not environmentally-friendly per se, on the con-

trary, they support incumbent production and consumption patterns.

• Integrated eco-innovations. They are aimed at creating cleaner production processes and products, usually focused on eco-efficiency and increasing productivity.

• Alternative product eco-innovations. They represent a new technological path that is more environmentally-friendly than an existent product, such as renewable energies and organic agriculture.

• Macro-organizational eco-innovations. They represent new solutions to organize society in a eco-efficient way. They require new functional interrelations (industrial symbiosis, urban ecology) and emphasise the spatial, organizational and institutional dimensions of eco-innovation. They are not radical from a technological point of view and usually depend on public authorities.

• General purpose eco-innovations. They refer to the technologies that define the techno-economic paradigms in a specific time frame (ICT, biotechnologies, nanotechnologies).

All of these types of eco-innovations interact and play different roles in the process of eco-innovation along the time; hence, they have an important role to play in the journey towards Circular Economy.

In a more recent review (Kiefer et al., 2017), it is highlighted that environmental impact of eco-innovation is united to other organizational effects, affecting the company and all stakeholders along the supply chain. This view is relevant to introduce another key concept, the business model, which will be discussed in the next section.

Discussion: eco-innovation and business models role in the circular economy

This section starts with an overview and reflection on the role of eco-innovation in the transition towards a Circular Economy. The following sub-section focuses on circular economy business models and their role as catalysers for eco-innovation and drivers for a Circular Economy.

Eco-innovation for Circular Economy

The idea of Circular Economy as a new paradigm of socio-economic development suggests that the current system needs to be transformed. As indicated previously in the introduction, there are different approaches towards systemic change: the first approach would trust in gradual changes while the second approach would try to radically transform the system. The latter requires changing the rules of the game, so a great coordination and commitment on the system level would be necessary.

The Eco-innovation Observatory (EIO, 2013) distinguishes both approaches with regards to the role of eco-innovation leading to a systemic change. A systemic eco-innovation by design

would imply the restructuring of the economic systems, besides companies, infrastructure and governance structures. In this sense, a new concept of value needs to be developed. The EIO indicates that businesses could include not only value creation but also value recovery. Following the definition of Circular Economy provided by Stahel (2013), value needs to be broaden to also include value optimisation and value preservation.

The design of a systemic change requires the interaction of different actors to plan and realise concerted action. In particular, communication and cooperation have been pointed out as the key elements enabling the development of Kalundborg industrial symbiosis network. The planning of eco-cities also shows that some kind of acknowledged standards are necessary, including the fulfilment of certain requirements such as local sourcing of required material resources and zero waste strategies, a high share of renewable energy or energy autarchy, public transport systems and low carbon solutions, and support for local and regional agriculture. In the same vein, restructuring mobility systems is supported through the concerted action of market-based policy instruments, the adaption of new technologies and alternative transport modes and business models.

Those examples show that a systemic change by design implies planning and coordinating changes at the technical level (infrastructure, technology, tools, production processes, etc.) and at the societal level (societal values and attitudes) as well as the creation of new markets.

A different approach to systemic change is based on a small change at the product or the technology level or a combination of small changes that lead to system-wide impacts. The EIO suggests that the cascade of four different de-coupling processes may support the system shift towards sustainability:

- Strategies aimed at reducing the environmental impacts of resource use: substitution of higher impact-intensive materials for materials with lower impacts, and increasing resource productivity;

- Strategies aimed at increasing the services obtained from a certain amount of products: sharing, pooling and leasing schemes,

- Activities aimed at extending the product life

The three strategies indicate that the achievement of reduced environmental impacts is a matter of changing the structure and scale of the material input.

- Strategies aimed at increasing the wellbeing from the production of services, i.e. to get more well-being from fewer service units. This strategy is the most difficult one since wellbeing is a relative concept, affected by culture, values and belief systems. They are also called sustainable consumption strategies.

The shift towards Circular Economy, understood as a systemic change, needs the high level commitment with a shared vision of the need to reduce waste and shift towards renewable energies.

The role of eco-innovations to foster the transition towards Circular Economy has been sparsely researched. Eco-innovations with the potential to enable the transition to a resource-

efficient circular economy model include efforts to change dominant business models (from novel product and service design to reconfigured value chains), transform the way citizens interact with products and services (ownership, leasing, sharing, etc.) and develop improved systems for delivering value (sustainable cities, green mobility, smart energy systems, etc.) (Eco-Innovation Observatory, 2016 p. 11).

The EIO (2016) distinguishes between hardware and software eco-innovations as necessary for circular economy: the hardware refers to technologies and technical infrastructures that will allow to turn waste into resources; the software are the skills, expertise and business models that will turn this transformation into a business case.

As has been previously stated, Circular Economy has to do with sufficiency and material and resource efficiency. In this sense, there are two different types of resource efficiency: resource sufficiency through reutilisation and service life extension of manufactured capital; and material efficiency through recycling of materials. While the first strategies are product-specific (modular system design, components standardisation, eco-design), the latter strategies are material-specific: physical and chemical recycling, new processes. Eco-innovation is a vital element of all circular economy efforts.

Table 2
Types of eco-innovation for a circular economy

Type	Brief descriptions, examples and keywords
Product design eco-innovation	Overall impact on the environment and material input is minimised over the whole product's life cycle Allowing for recovery options like repairing, maintenance, remanufacturing, recycling and cascading use of components and materials
Process eco-innovation	Material use, emissions and hazardous substances are reduced, risks are lowered and costs are saved in production processes Advancing remanufacturing, such as Refurbishment by replacing or repairing components that are defective, including the update of products Disassembly and recovery at the component, material and substance level Upcycling, functional recycling, downcycling Zero waste production, zero emissions, cleaner production
Organisational eco-innovation	Methods and management systems reorganisation pushing for closing the loops and increasing resource efficiency New business models e.g. industrial symbiosis, new collection and recovery schemes for valuable resources From products to functional services (product-service systems)
Marketing eco-innovation	Product and service design, placement, promotion, pricing Promotion of the reuse for the same purpose (e.g. bottles, appliances), promotion of the reuse for different purposes (e.g. tyres as boat fenders, for play grounds) Eco-labelling, green branding
Social eco-innovation	Behavioural and lifestyle changes, user-led innovation Sharing (e.g. domestic appliances, books, textiles), collaborative consumption (e.g. flats, garden tools) sufficiency (e.g. plastic bag bans) Smart consumption, responsible shopping, use rather than own schemes
System eco-innovation	Entirely new systems are created with completely new functions reducing the overall environmental impact Leading to a substantial dematerialisation of the industrial society New urban governance, smart cities, permaculture

Source: EIO (2016) .

Adding to previous grey literature, some authors have very recently addressed the relation between eco-innovation and the CE. De Jesus et al (2018; 2018) states that eco-innovation appears to be an enabler of the transition to a CE, particularly organizational and process eco-innovations. Moreover, the authors conclude that the issue is still heterogeneous in the literature and accordingly, the innovation's system view should still be considered when transition to a CE is investigated (2018).

In the later scientific literature it is indicated that, in order to understand the role of eco-innovation as a driver of a CE, still some research gaps need to be addressed, such as the specific tools through which eco-innovation contributes to transformative and systemic change required by the CE paradigm. Building on that, the role of business models is discussed in the next sub-section.

Circular economy business models

It is argued that in order to promote a really sustainable pathway, radical and systemic innovations are needed; changing production and consumption patterns that involve social and institutional innovations are considered fundamental to the achievement of this aim (Smith et al., 2010). "Such systemic (or transformative) innovation is more likely to take place beyond the boundaries of one company or organization as it often requires the transformation, replacement or establishment of complementary infrastructures. […] One of the imperative conditions for such innovation is social and cultural change, adopting new values and behaviour both on the producer and consumer side" (OECD, 2012, p. 4).

It has been suggested that in sustainable innovation studies there is a gap between those on the level of companies and those on the overall level of societies that is missed. Boons, Montalvo, Quist, & Wagner (2012) argue that the concept of business models may form the necessary intermediate link.

Alex Osterwalder's seminal publication (Osterwalder et al., 2005) and follow-on book 'Business Model Generation' (Osterwalder and Pigneur, 2010) provide the following definition:

A business model describes the rationale of how an organisation creates, delivers and captures value. Osterwalder describes this using the Business Model Canvas – a framework that creates a common language for understanding and discussing business models. This framework has been adopted internationally by practitioners in the business world.

According to the OECD the business model is the key to determining the success of eco-innovation, as it brings eco-innovation out to the market and promotes its dissemination. "The business model perspective is therefore particularly relevant to radical and systemic eco-innovation, including how business models and strategies can induce and help diffuse radical eco-innovation and enable systemic changes and transformation" (OECD, 2012, p. 6).

The business model seeks to explain both value creation and value capture. The business model acts as a mediator between technologies of production and consumption, i. e. between how technological artefacts are made, the artefacts themselves, and how they are finally used. This role as market device can refer to three combinations of business model and technology innovation:

- Existing products are offered in new ways; e.g. based on new modes of distribution

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and application. The main challenge in this combination is to convince customers of a new product or service handling.

• Integration of new production processes, products or services with a company's existing business model.

• Marketing a technological system innovation through new business models. For example, selling shared transportation services.

Therefore, business models have two functions regarding eco-innovation: i) they can support the strategic marketing of innovative processes, products and services; ii) they can change the terms of competition by restructuring the value chain and generating new types of producer-consumer relationships, besides altering the consumption culture and use practices.

However, business models as such do not say anything about environmental and social consequences of creating and delivering value. In this sense, Lewandowski (2016) suggests a framework combines the components of the business model canvas as designed by Osterwalder & Pigneur and the Resolve framework on how to implement the Circular Economy principles. The business model for circular economy has the nine following components:

(1) Customer segments that an organization serves;

(2) Value propositions that seek to solve customers' problems and satisfy their needs;

(3) Channels which an organization uses to deliver, communicate and sell value propositions;

(4) Customer relationships which an organization builds and maintains with each customer segment;

(5) Revenue streams resulting from value propositions successfully offered to customers;

(6) Key resources as the assets required to offer and deliver the aforementioned elements;

(7) Key activities which are performed to offered and deliver the aforementioned elements;

(8) Key partnerships being a network of suppliers and partners that support the business model execution by providing some resources and performing some activities;

(9) Cost structure comprising all the costs incurred when operating a business model

Several organisations have tried to classify business models for Circular Economy. For instance, *Accenture* (Lacy et al., 2014) identifies five types:

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• Circular supplies: provide renewable energy, bio based- or fully recyclable input material to replace single-lifecycle inputs;

• Resource recovery: recover useful resources / energy out of disposed products or by-products;

• Product life extension: extend working lifecycle of products and components by repairing, upgrading and reselling;

• Sharing platforms: enable increased utilization rate of products by making possible shared use / access / ownership;

• Product as service: offer product access and retain ownership to internalise benefits of circular resource productivity.

IMSA Amsterdam (van Renswoude et al., 2015) offers a different classification, where business models are related to six different archetypes: short cycle (e.g. pay per use, repair); long cycle (performance based contracting); cascades (upcycling, recycling); pure circles (cradle to cradle); dematerialised services (physical to virtual); produce on demand (produce on order, 3D printing).

According to Stahel (2013) the business models based on selling goods as services or performance are the most profitable and resource-efficient in the Circular Economy. Through its focus on system solutions, they internalise risk and waste costs. Moreover, the retention of ownership of goods and embedded resources creates corporate and national security of resources.

Based on literature review, Figure 3 offers a synthesis of business models for circular economy combined with the nature of eco-innovation that may play a role as an enabler of a Circular Economy.

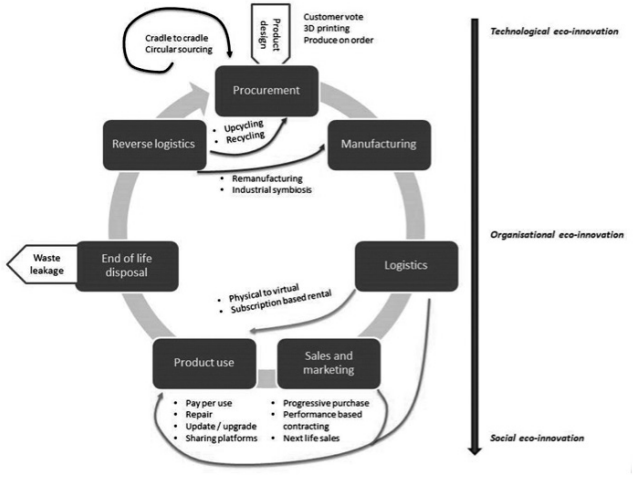

Figure 3. Circular Economy Business Models – focus on producer / consumer side and nature of eco-innovation

Figure 3 places different circular business models in close relation to different stages of the supply chain. Some business models are exclusively referred to the producer side, and are basically aimed at reducing and optimising the use of materials in production processes. There are some more business models that concern the user side, and are aimed at extending product life, intensifying product use through sharing and pooling schemes, and substitution of services for products. The different colours indicate the key supply chain phases involved in the business model. Moreover, depending on the business model the type of eco-innovation also varies. Technological eco-innovation affects business models focused on the producer side, while social eco-innovation is required when the consumer side is the focus of business models.

Business models represent an important tool, which, independently on their innovative profile, may pave the way towards Circular Economy. Not all business models in a circular economy are necessarily innovative: some of them may be focused on the circular economy; while others may take part of the circular economy because they use the infrastructures, products or services that enable the circular economy (EIO, 2016).

In any case, business models may play crucial functions, such as:

- Provision of basic infrastructures: collection systems or platforms linking the demand and supply side in order to enable waste-as-a-resource procedures or the distribution and use of secondary raw materials.

- Facilitation of benefits from cross-border, cross-industry and cross-sector reach, and from global supply chains;

- Support to businesses decision making: provision of tools to clarify to what extent is reusing, repairing, remanufacturing, recycling or selling the right treatment for a product, component or material;

- Support of eco-innovations in the field of consumption: sharing products or infrastructures, consuming services rather than products, using IT or digital platforms, web-based applications.

Some activities are especially useful for shifting towards the Circular Economy (O'Brien *et al*., 2014) and the role of eco-innovation may be of varied relevance:

Eco-design focuses on designing physical objects, the built environment and services with consideration for their environmental impacts during their whole life cycle. Thus, it is a process that explicitly aims at developing an eco-innovation (O'Brien *et al*., 2014).

Eco-design may affect several parameters during the product life cycle and thus offering different opportunities for the Circular Economy: design low-impact manufacturing and remanufacturing options; ease the separation of raw materials for recycling; design re-usable products; predefine the selection of sustainable inputs and low-impact materials; optimise storage and distribution systems. Eco-design is also the basis for designing new business models focused on providing services and dematerialized solutions rather than products.

Maintenance and repair: while repair aims at correcting a specific fault in a product / component and returning it to satisfactory working condition, maintenance is focused on

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prolonging system availability. Both concepts are approaches used to promote service-based business models, such as leasing and sharing.

Maintenance and repair are considered important enablers of more sustainable consumption practices. In particular, citizens, small companies and communities are encouraged to undertake initiatives with a focus on reusing rather than on throwing away. The approach is also socially and economically interesting in the case of large infrastructures and buildings.

Re-use: this approach focuses on keeping material flows within the economy, meaning that products or components that are not waste are used again for the same purpose for which they were conceived. Re-use also has to do with social eco-innovation, since it especially requires changes in consumption and disposal behaviour.

A different re-use approach is cascading. It consists of using biomass as a material and re-use it as long as possible before finally recovering the energy content from the resulting waste.

Re-manufacturing: the objective of this strategy is to return an end-of-life part or product to like-new or better performance. Eco-innovation in re-manufacturing usually influences product design and business models (O'Brien *et al.,* 2014).

Recycling: it is the recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.

All of those activities may give place to business models, based on new products and / or services, and be an instrument to promote changes in production and consumption patterns.

Business models combine all the core components of business strategies and operations that create and deliver value to the customers as well as to the firm. Within the context of a transition towards the Circular Economy, business models are important drivers. Notwithstanding, business models for circular economy are not necessarily based on eco-innovations.

Conclusions

Eco-innovation is defined as any innovation aimed at getting a reduction of environmental impacts. Scholars argue that eco-innovation offers the chance to get a double win, since it helps to improve the environment and at the same time it offers opportunities for businesses to get a competitive advantage. However, environmental and economic gains are not always compatible and some trade-offs may be necessary. Especially, eco-innovation may generate rebound effects, for instance, a larger production and diffusion due to increased productive efficiency and a diversity growth (new green sectors, new green products) may contribute to increase consumption. For this reason, systemic and complex thinking is necessary to understand the role of eco-innovation as an enabler of Circular Economy.

Circular Economy represents a promising approach to a sustainable transition from the linear economy, the current socioeconomic paradigm. The transition to a Circular Economy represents a systemic change and a broad systemic innovation, involving new knowledge, new technologies, new regulations, new institutions, new business models, new financial rules and new consumption behaviours... As such, it entails the necessity to address some specific challenges. In particular, the objective of the Circular Economy is to reduce resource consumption and waste, maintain and to share value along the time, rather than adding value. Systemic change may be addressed from different perspectives, usually top-down and bottom-up approaches are distinguished. In any case, eco-innovation (new technologies and, in particular, eco-design in products and processes and new business models) has an important role to play as an enabler of the Circular Economy.

The important aspect that emerges from the literature overview is that the shift towards Circular Economy requires taking into account systemic thinking, especially to note the importance of synergies, cooperation and rebound effects. For this reason, the role of eco-innovation must be carefully considered. Eco-innovation promises a double gain (economic and environmental benefits), it may support increased productive efficiency, increased production and diffusion, as well as increased diversity (new products and new services. However, those apparently positive effects need to be contrasted with rebound effects such as increased consumption of the same or new products, the transference of impacts from one stage of the supply chain to another one, and the green consumerism linked to planned obsolescence. These undesired consequences working against the Circular Economy principles have to be avoided.

Eco-innovation for Circular Economy can be of technological and non-technological character. Indeed, it is acknowledged that Circular Economy needs to address important challenges regarding business models and socio-institutional frameworks, while technological change may not be necessarily radical. Some authors distinguish between soft and hard eco-innovation to remark the importance of changing skills, behaviour and business models, besides technologies and infrastructure, in order to support the transition towards a Circular Economy.

This paper has contributed to the field of the relation between eco-innovation and Circular Economy by adding to the previous scientific literature the discussion on the role of circular business models. The concept of Circular Economy Business Model is a useful instrument in order to operationalize the transition to a Circular Economy paradigm. It is also a useful intermediary concept to identify the different ways for eco-innovation: technology innovations, organizational innovations, social innovations and consumption innovations. In order to pave the way to Circular Economy through eco-innovation, business models are considered a key instrument. The business model is seen as a holistic approach towards the way of doing business. Overall it is defined as the way of creating, producing and delivering value. From the eco-innovation perspective, a business model needs to add ecological and social value to the value proposal and changing the producer and the consumer practices. The business model is key to channel eco-innovation in the market and, in support of different activities, modify production and consumption patterns. Circular Economy Business Models should be focused on activities that follow the hierarchy reuse, repair, remanufacture and recycle, consider the geographical dimension and trying to increase value preservation as much as possible. For business models to work and to foster real shift towards Circular Economy, an important support from policy is also necessary. In particular, the good performance of business models cannot be achieved without functioning markets, including those necessary for products life extension, used goods and for resale of goods and components. Moreover, Research and Innovation Policies have to shift from a simple *intensity* focus to another prioritising the *direction* of innovative activities, targeting environmental issues.

Therefore, for the future papers, important topics to deal are the modification of legal and regulatory frameworks and, of course, the overall shift in the tax system architecture in order to favour circular resources (e.g., labor and renewable resources) instead of non-renewable resources.

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