



## NEW CONCEPT OF DIGITAL INNOVATION ECOSYSTEM IN BOOSTERING CIRCULARITY DEVELOPMENT TWILIGHT OF TRADITIONAL BROKERAGE OF INNOVATION


**Ewa Kochanska\***

Research and Innovation Centre Pro-Akademia  
9/11 Innowacyjna str., 95-050 Lodz, Poland, [ewa.kochanska@proakademia.eu](mailto:ewa.kochanska@proakademia.eu)  
 <https://orcid.org/0000-0002-4735-7969>


**Iwona Adamkiewicz**

Research and Innovation Centre Pro-Akademia  
9/11 Innowacyjna str., 95-050 Lodz, Poland, [iwona.adamkiewicz@proakademia.eu](mailto:iwona.adamkiewicz@proakademia.eu)  
 <https://orcid.org/0000-0003-2272-802X>


**Katarzyna Wozniak**

Research and Innovation Centre Pro-Akademia  
9/11 Innowacyjna str., 95-050 Lodz, Poland, [katarzyna.wozniak@proakademia.eu](mailto:katarzyna.wozniak@proakademia.eu)  
 <https://orcid.org/0000-0002-9871-732X>

**Marcin Podgórski**

University of Lodz, Faculty of Economics and Sociology  
3/5 Polskiej Organizacji Wojskowej, 90-255 Lodz, Poland, [marcin.podgorski@uni.lodz.pl](mailto:marcin.podgorski@uni.lodz.pl)  
 <https://orcid.org/0000-0003-2054-194X>

**Zbigniew Przygodzki**

University of Lodz, Faculty of Economics and Sociology  
3/5 Polskiej Organizacji Wojskowej, 90-255 Lodz, Poland, [zbigniew.przygodzki@uni.lodz.pl](mailto:zbigniew.przygodzki@uni.lodz.pl)  
 <https://orcid.org/0000-0001-6964-8479>

*Article history: Received 4 July 2023, Received in revised form 24 July 2023, Accepted 24 July 2023, Available online 24 July 2023.*

### Highlight

The article deals with the new paradigm of circularity brokering in context of the current socio-economic and IT megatrends of development.

### Abstract

The aim of the paper is to identify the direction of evolution, the conditions of organisation and the impact of the new concept of digital innovation ecosystem in boosting circularity development. The traditional model of innovation brokerage and the new circularity broker paradigm in the development of the circular economy is presented. The authors discuss the circularity broker as an IT interface, equipped with wide range of IT tools, and above all, self-learning applications with AI elements. The circularity broker is accompanied by its watch dog, i.e., a set of IT tools used to search, process and transfer information dedicated to specific stakeholders, exactly when they need this information. The concept of circular brokerage is anchored in the area of the regional clusters dedicated to circular economy development.

### Keywords

a broker of innovation; circularity; megatrends; interface.

### Introduction

The role of brokerage has been conceptualized in literature already in the twentieth century as relationships bridge the gaps between social, business and academia worlds. Duncan J. Watts [1] and Mark S. Granovetter [2] stated that the essence of brokerage is an “intensive” search for information about a specific opportunity versus an “extensive” approach, exploiting well known revenue streams of homogeneous information, specific for only one activity. People used to focus on activities inside their own group and on the single activity, what impacts the gaps in information flow between groups, or more simply - creates structural holes [3]. The information or knowledge that cannot be transferred to other actors is kept - consciously or not - by its possessor

and maintains its original value. Brokerage entails bridging structural holes, i.e., “joining previously unconnected parties to facilitate coordination, collaboration and the pursuit of common goals” [4]. Brokering, defined in this way is seen as a revolutionary opportunity for the development of innovation and technology by facilitating the flow of dedicated information between industry and scientists and establishing stable, long-term relations, beneficial for both sides. Therefore, innovation or technology brokers get their chances to be a promoter of innovation.

Innovation broker as a profession appeared on the labor market in 2006 and was defined as an intermediary/agent in the innovation process between science and industry. As part of his duties, the innovation broker was to assist in disseminating information about new technologies and inventions in scientific institutes and about the needs of enterprises in the field of new products, technological processes, work organization, etc. An important task of broker was advising on fundraising [5]. For two decades, innovation brokering has been identified as a profession, hence - the innovation or technology broker was a concrete man, practicing this profession.

Innovation or technology brokers in the EU and US were bounded especially with universities. The task of the innovation broker was to obtain data from scientists, research groups as well as entrepreneurs about their information needs or about their offers, and then - to select, process and transfer the tailored information to the appropriate recipients. The innovation broker was expected to also use information sources such as scientific publications, industry magazines, conference presentations, trade fair offers, etc. Therefore, effectively fulfilling such wide-ranging and extremely complicated tasks by innovation and circularity brokers is a challenge indeed. In Guidance on Innovation Procurement (2021/C 267/01) [6] the problem of how to mobilize innovation brokers was discussed. The European Commission states that the links between companies, including start-ups and innovative SMEs, offering innovative solutions on the one side, and public buyers, on the other side, are often weak and do not arise spontaneously. Innovation brokers, as being a part of the overall innovation life cycle, are expected to build or strengthen the ecosystem of innovation. Within the above Guidance, the EC suggests that brokers should e.g., advise public buyers on how to join the networks to share knowledge, exchange good practice and communicate to the market (e.g., market consultation, joint commitment for future innovation procurement). A literature review of innovation brokerage practices and analysis of the authors' experience with innovation and technology brokering indicate that we should create a new brokering paradigm that aligns with current socioeconomic mega trends [7].

How does the new paradigm of circularity brokers address the circular development megatrends?

Innovation in the circular economy is considered an essential factor for achieving development while reducing resource consumption. This is confirmed by researchers both on the ground of theory: The green economy, Green growth, Decoupling the growth, Degrowth, or steady-state economy [8–10]. Accordingly to the European Parliament (EP) definition [11], that “circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible”. In other words: circularity means that you should strive to minimize the generation of waste, and if the product's life is coming to an end, the materials from which it was made should be reused, repairing, refurbishing and recycling, thus - returned to the market. You should look for ways to use them again in order to create additional values. The circular economy paradigm implementation helps to replace the traditional, linear economic model, based on a “take-make-consume-throw away” pattern, consuming large quantities of natural resources, materials and energy.

In practice, the circular model of socio-economic development should imply reducing waste to a minimum. It is in line with the concept of the waste hierarchy as given in Figure 1. The main idea of the waste hierarchy model is to prevent/avoid things becoming waste in the first place [12]. It is essential and the most preferred option in the waste hierarchy. Less waste means less need to reuse products, less disposal and most importantly, less waste at landfill sites.

The European Commission's 2008 Waste Framework Directive [13] introduced the term “4R”: Reduce, Reuse, Recycle and Recover. Since then, researchers have proposed R - frameworks beyond the 4Rs, such as 6Rs [14] or even 9Rs [15]: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover [6].



Figure 1. Traditional Waste Hierarchy Concept. *Source: Authors, on the basis [12].*

How does the new paradigm of circularity brokers address the on-demand development megatrends? On-demand economy is defined as the instant and pervasive access to goods and services, tailored to meet the individual's needs [16]. In the last decade, social and economic habits have changed dramatically. The immediacy of our connected world, thanks to instant communication, media and trade, powered the sense of entitlement of all B2B and B2C market participants to immediately satisfy needs [17,18].

On-demand economy megatrend is radically changing the way we transact in the market at the global level and revolutionizing business models, in which companies manage their production and service delivery. At the same time, individuals are radically changing their lifestyle. Under pressure of the On-demand economy rules, decision making processes, concerning both daily and long-term issues, purchases and interactions with the labor market are changing. They must be faster and should consider the rapid pace of changes in the market. The on-demand economy will experience exponential growth in many aspects of the economy and social life, e.g., the amount of every-day information processing. This new paradigm shift is analogous to the disruption imposed by the internet boom. Now, our needs and desires become instantly achievable through the speed and convenience of execution just as the Internet revolutionized the way we acquire knowledge in the late 1990s. The implementation of the on-demand economy paradigm and the reorganization of the global market enable or facilitates new processes of production, delivery or organization, but fundamentally redefines the size, scope and role of industry. For sure, information technologies development and dissemination are essential for these changes.

We can see how digital facilitation contributes to an exponential increase in the speed of transactions, expanding the pool of potential service providers and sellers. Online technologies are a tool to change the way and rate of participants' engagement in a particular transaction. Therefore, in the conditions of an over-exponential growth of available information, on-demand economy, equipped with ICT communication tools, building and maintaining an industrial symbiosis becomes problematic. There is no need any longer to be bound by long-term contracts, while the economic world offers volatile opportunities that are easy to take advantage of. However, a fundamental asset is to have access to an information base, tailored to our needs and, what is more important, competence on how to use it, facing on-demand economic challenges.

How the new paradigm of circularity brokers addresses the collaborative development megatrends? Already in 2016, the European Parliament noticed, that "The arrival of collaborative economy is associated with many benefits for consumers and the economy as a whole" [19]. Collaborative economy is defined [17] as "a marketplace where consumers/clients create specific nets to meet their wants and needs and consists of giving, swapping, borrowing, trading, renting, and sharing products and services for a fee, between an individuals or companies who have something and an individuals or companies who need something - generally with the help of a web-based intermediary". A collaborative economy may also be known as a "shared economy," "sharing economy," or a "peer-to-peer economy." Tempo of implementation of the collaborative economy paradigm, which is observed in last few years, was affected by two complex groups of causes [20]:

- firstly: *increasing public awareness*: growing concern about climate change and growing interest in environmental issues - extreme heat waves and droughts caused by climate change, forest fires, hurricanes, floods, etc.;
- secondly: *global economic and social crises*: because of the Covid-19 pandemic, traditional, long supply chains have collapsed and in many areas of the economy there has been a turn towards a centripetal direction, i.e., local, quasi-autarkic economic development, based on the local potential, including underused resources, better waste management and social inclusion. The war in Ukraine and in the consequence the embargo imposed on Russian energy resources caused a crisis on the energy market and consequently on the food market. Inflation has risen dramatically all over the world.

The Collaborative economy could be an answer to the above-mentioned global challenges. Five key sharing sectors (P2P finance, online staffing, P2P accommodation, car sharing and music/video streaming) have the potential to increase global revenues from around \$15 billion now to around \$335 billion by 2025. In the UK, these five sharing sectors could generate revenues of around £9 billion by 2025 [21]. It is worth to quote a statement of Veronique Laury, CEO of Castorama [22]: "Most retailers missed the first revolution in retail that digital technology brought: e-commerce. I am determined not to miss the second one: which I believe is collaborative consumption. We will not be just a retailer in the future – we will be an organization helping you to improve your home."

The Collaborative economy and collaborative consumption are driven by the development of information, communication and cloud computing technologies, growing consumer awareness, the creation of collaborative online communities as well as social media trading/sharing [23].

Collaborative Economy sectors differ from traditional ones in three basic features [21]:

- business models are hosted via digital ICT platforms that combine demand and dynamically share bandwidth in real time;
- transactions are made through various methods that offer access instead of full ownership, such as: sharing, subscription, resale, swap and P2P;
- shoppers like individuals, but as well as companies and local administrations are more comfortable and feel more connected and locally anchored, being provided with products in a way that involves deeper social interaction than traditional methods of trade and exchange.

The Collaborative economy results in the so-called social inclusion, engaging not only the main stream of social potential in the implementation of the principles of the Circular economy, but also activating "by-social potential" and "by-regional potential" [24].

How does the new paradigm of circularity brokers address the app-driven development megatrends? Starting in 2008, Apple set the cornerstone for the app-economy vision and coined its widely touted and trademarked slogan "There's an App for that." The app economy ideas quickly migrated to Android and mobile platforms. Since then, tens of billions of mobile apps have been designed and downloaded. Generally, the app-driven economy refers to the range of economic activity performing in digital space and surrounding mobile applications. Mobile apps and cloud computing technology created new opportunities for entrepreneurs and changed the way business is done. Cloud computing technology gives users access to storage, files, software, and servers through their internet-connected devices: computers, smartphones, tablets, and wearables [25].

Already in 2012 Ray Kurzweil, the Google engineer and futurist said in an interview with the Wall Street Journal, entitled "Technology and the New, Improved You", that "A kid in Africa has more technology at his disposal than the president of the United States did 15 years ago" [26]. A dramatic increase in the number of new business platforms, as well as in smartphone connected consumers, simplify and secure purchase flows, enables explosion of new types of business models, represented by such business as: Uber - the largest transport company without its own cars, Alibaba, Amazon - the world's largest wholesalers without its own stationary stores, Airbnb – the largest tourist network without its own hotel base and many other cases. The digital transformation, guided by the app-based economy, is speeding up changes in the global socioeconomic environment. It has a significant impact on many areas of life, including private life and social inclusion, social activity, but also public administration, industrial structure and business networks [27].

Essential to an app-economy and a collaborative economy as well as an on-demand economy and finally – a circular economy development is business platform, managed by a company or group that acts as an intermediary to facilitate consumers' ability to rely on each other. Hence, new brokers of circularity

are expected to support on-demand, collaborative and first of all – circular economy development. The feasibility of these complex tasks is possible only when properly tailored IT computing tools are implemented in the circularity ecosystem. Thus, in the new brokering of circularity paradigm, current development trends are orchestrated.

In line with the new paradigm of brokerage, the brokers of circularity should be defined as the interfaces between all stakeholders of the regional or local circularity development. Their main tasks are translation the different languages [28] of the several entities and align information needs with outputs [29]. The broker as interface is not understood any longer as an external person or even an external institution to the organization or company, but rather as its internal officer, equipped with the IT toolkit for dealing with the information of the organization needs just in time and addressing its specific demand. On the other hand, a circular broker [12] as an interface should have easy access to database with full information convenient for boosting a regional circular development. We are talking about two-way access here: the broker should be able to use the database for his specific purposes, but also provide information to the database himself. The other brokers will be able to use such data immediately.

### **Methods**

Analysing global socio-economic trends, the global climate crisis and the resource crisis are determining revolutions in the organisation of markets, influencing the reorganisation of political objectives at every level of government and shaping new patterns of social behaviour. These changes create a unique demand for innovation. This demand affects businesses, citizens, and authorities. Hence, the paper makes the research assumption that we are facing the twilight of traditional innovation brokerage. Consequently, the following research hypothesis was stated and discussed: The complex nature of the circular economy calls for a specific type of brokerage. It requires one that can create and spread innovations by providing remote, direct access to market partners and straightforward advice.

A triangulation of research methods was used to verify the research hypothesis and realise the adopted objective. This hypothesis was verified based on the results of the research: (1) diagnostic (reactive), (2) desk research (non-reactive) and (3) case study analysis.

The first, diagnostic research, was carried out based on the Frontsh1p project (Horizon 2020) and concerned the identification of conditions for the functioning and implementation of the circular economy at the level of the circular cluster. Their subject matter covered: identification of legal and legislative barriers to CE implementation; market failure in CE; incentives for CE; Green Public Procurement; interoperability of databases useful for CE; and conditions for optimising the public governance model for CE. The results of these studies are not the direct subject of this paper, but they served the authors to conceptualise and formulate the aim of the paper and the research hypothesis.

The results of the desk research and case study are the direct subject of analysis in this paper. The desk research analysed scientific publications, reports, and legal resources. They focused on innovation brokering for creating and spreading innovation and transferring technology in the circular economy. The case study analysis was based on 5 case studies of institutions - innovation brokers. From a spatial perspective, the analysis focused on institutions directly influencing the area of the circular cluster in the Lodzkie Region.

From a functional perspective, purposive selection was used in this case to obtain the opinion of innovation brokers regardless of the sector of activity and type of ownership of an organisation. The research was carried out at the following institutions:

- Technology Transfer Centre of the University of Lodz (public entity, R&D unit),
- Research and Innovation Centre Pro-Akademia (non-governmental organisation, R&D unit),
- Foundation for Enterprise Development (non-governmental organisation, training, and consulting unit).
- Technopark Lodz (government public entity, regional development agency);
- Center for Innovation and Technology Transfer of the Medical University (public entity, R&D implementation unit).

Case study research was carried out using in-depth interviews (IDI). The main research (IDI) aim was to gather experiences and opinions on the effectiveness of innovation brokers' work, employed in the interviewed institutions. These assessments were more than critical, although the institutions participating in the interviews

emphasized that the low effectiveness of brokering in the traditional sense was the result of the brokerage formula not being adjusted to present-day economic, technological and, above all, information challenges.

### **Results and discussion**

Circular economy (CE) and a special role of circularity development brokers' topics include developing waste management that promotes new business models, design thinking, and a more productive approach to consumption and production, according to current research. Since the industrial revolution, we have lived in a linear economy [30]. Transition is necessary to move away from the linear economy that has been prevalent since the industrial revolution. Current research [31,32] highlights the importance of circular economy (CE) principles, which encompass innovative waste management practices, the adoption of new business models [33,34] and another efficient approach to consumption and manufacturing [35,36]. The linear economy follows a "take-make-dispose" model, where resources are extracted, transformed into products, and eventually discarded as waste. This approach leads to resource depletion, environmental degradation, and the accumulation of waste [37]. In contrast, the circular economy aims to decouple economic growth from resource consumption by promoting the principles of reduce, reuse, recycle, and regenerate [38,39]. It emphasizes the importance of designing products and systems that are durable, repairable, and easily recyclable, thereby minimizing waste generation.

In this ecosystem, circular economy principles are seamlessly integrated with digital technologies. This synergy gives rise to creative solutions that have the potential to generate cost savings. In addition, it aims to improve resource management, reduce waste, promote sustainable economic growth and open new avenues for income generation. As companies transform their traditional business models into digital ones, they prioritize resource allocation and seek to minimize resource consumption, thus adapting to the principles of the circular economy. This shift is critical to their long-term viability and growth in the market. Digital technologies play a key role in facilitating this transition by enabling efficient tracking, monitoring and sharing of resources. They enable businesses to move smoothly along the path to circular practices. This shift can lead to cost savings, better resource management and new revenue streams. In addition, digital technologies such as the Internet of Things (IoT), artificial intelligence (AI) and block chain play a key role in enabling transparency, traceability and accountability within the circular economy. They enable real-time data collection, analysis and decision - making. This improves resource optimization, waste reduction and circular supply chain management. Accordingly, the European Commission's Circular Economy Action Plan explicitly recognizes the importance of digital technologies to accelerate circulation. They enable real-time data collection, analysis and decision - making. Third, the convergence of digital technologies and sustainable development is very important in various industries.

Digital platforms support the development of innovative business models and collaborative ecosystems. For example, sharing and rental arrangements make optimal use of resources and reduce waste. Products, business models and value chains can be systematically redesigned using various digital technologies, resulting in lower material and energy consumption. This strategy allows customers to engage in the circular economy by providing them with information about the origin of items and their impact on the environment throughout their life cycle.

The predominant approach to Circular Economy focuses on technical and engineering aspects [15] or economic and environmental ones but tends to overlook the social dimension of CE. Existing reviews of CE have highlighted deficiencies in the current conceptualization, specifically the lack of emphasis on social and institutional dimensions, which are considered crucial for the comprehensive development of the CE concept [40]. The advancement and execution of CE initiatives are heavily dependent on broad-scale collaboration within society [41].

Transitioning to a circular economy requires systemic changes across various sectors and stakeholders [42]. The new paradigm of circular brokers activities involves rethinking production processes, implementing sustainable waste management practices, fostering collaboration among businesses, policymakers, and consumers, and promoting innovative technologies and business models. The adoption of circular economy principles can bring numerous benefits, including the reduction of waste generation, the preservation of natural resources [14], the creation of new business opportunities, especially in virtual reality, and the mitigation of environmental impacts [13]. It can also contribute to the development of a more sustainable and resilient economy addressing the current global socio-economic megatrends. A transition, according to Schlossberg [43],

is any event or non-event that results in altered relationships, routines, assumptions, and roles. It is vital to emphasize that perception is important in transitions since an event, or non-event, satisfies the criteria of a transition only if the individual experiencing it defines it as such. In a multi - level governance, the roles of transition may vary depending on factors such as the timeframe, content, and context of the transition. To comprehend the significance of a shift for a certain individual, the kind, context, and impact of the transition must be addressed [44]. Transition brokers have a vital role in facilitating and coordinating the shift towards a circular economy [38]. They act as orchestrators within the system, actively participating in processes of change and striving to establish alliances and collaborations among diverse stakeholders.

Monitoring and evaluating the progress of the transition is another crucial aspect of the process. Assessment of the impact of circular initiatives, identify valuable insights, and share best practices with relevant stakeholders. Overall, transition brokers act as catalysts for change by bringing together stakeholders and resources, facilitating collaboration, and driving the transition towards a circular economy. Their impartial stance, expertise, and ability to navigate complex systems make them instrumental in accelerating the adoption of circular practices and fostering sustainable and resilient economies. An essential function of transition brokers is to establish the necessary environment for the desired evolution, identify barriers and opportunities within the current system and work towards overcoming obstacles, creating a condition encouraging circular initiatives. This can involve advocating for supportive policies, regulations, and financial mechanisms that incentivize circular practices. Transition brokers also contribute to the development of impactful circular initiatives. Bringing together a wide range of stakeholders, including businesses, government entities, academia, and civil society, enable to collaborate on the design and implementation of circular solutions. By adopting a neutral standpoint, transition brokers facilitate dialogue, consensus-building, and the co-creation of innovative strategies and projects. Brokers can serve as facilitators, mediators, knowledge brokers, network builders, or project managers [38,45]. Their focus is on fostering collaboration, promoting the exchange of knowledge, and ensuring the effective implementation of circular economy principles.

Brokers can pursue four brokerage strategies [46]:

- coordinate activities or information between distant parties with no immediate prospect of direct introduction or connection;
- proactively maintain and exploit the separation between parties;
- introduce or facilitate existing ties between parties so that the coordination role of *tertius iungens* gradually fades (short-term connection);
- create or encourage interaction between parties while continuing to play an important coordinative function over time (persistent iungens).

Thus, at its core, brokerage is focused on this idea of bringing together people or groups who may not have direct connections, to create value through facilitating interactions. Brokers are expected to bridge gaps, mediate relationships, and provide access to resources or opportunities that would otherwise be out of reach for those involved. They are considered instrumental in promoting innovation, sharing knowledge, and fostering collaboration. While it is widely acknowledged that brokers play a vital role in enabling connections, collaborations, and the exchange of information, the actual realization of their impact leading to success is not frequently observed. However, the belief that brokerage behaviour alone guarantees success is often met with scepticism when examined empirically. While brokers may possess the necessary skills, networks, and knowledge to connect diverse individuals or groups, the outcomes of their efforts can vary significantly. This disparity can be attributed to several factors, including the intricate nature of social interactions, contextual limitations, individual motivations, and the unpredictable dynamics within networks. In other words, the success of brokerage endeavours is influenced by a multitude of complex and ever-changing elements that go beyond the mere act of connecting others.

Brokers act as intermediaries who bridge the gaps between different groups or organizations, enabling the transfer of information, ideas, and expertise [47]. They go beyond simply connecting individuals or groups; they actively work to develop mechanisms and structures that facilitate effective communication across boundaries. One-way brokers achieve this by developing work practices that promote information sharing and collaboration. They identify and establish common processes, methodologies, and tools that enable individuals from different groups to work together efficiently. These work practices may include regular meetings, workshops, or collaborative platforms where knowledge and insights can be shared. In addition,

brokers create repositories where relevant information and resources are gathered and made accessible to the involved parties. These repositories serve as centralized hubs of knowledge, capturing best practices, case studies, research findings, and other valuable resources. By curating and disseminating this information, brokers enable easier access and transfer of knowledge across groups.

One of the key functions of brokers is to help community members acknowledge and appreciate the perspectives of others. They actively listen to the concerns, values, and aspirations of each community and then translate and convey these messages in a way that can be understood and respected by other communities [48]. This process involves not only language translation but also cultural interpretation, ensuring that the nuances and subtleties of each community's perspective are accurately conveyed. Brokers also create opportunities for dialogue and interaction among community members. They organize meetings, workshops, and other collaborative activities where individuals from different communities can come together, share their experiences, and engage in meaningful discussions. Through these interactions, community members have the chance to learn from one another, challenge their preconceptions, and develop a deeper understanding and appreciation for the perspectives of other communities. Innovation brokers communicate and combine the global world with the local world perspectives. They facilitate and often enable the inclusion of local actors in transnational relationships. However, innovation is rooted, hence synergies are created for both the external environment and the local entrepreneurial environment.

A specific feature of the linear economy is the sectorial structure of business relations and the sectorial concentration of processes. Hence, the typical market mechanism for coordinating innovation processes was clustering in the sense of Porter [49]. Such an arrangement favoured processes of deepening specialisation. This also applies to the broker function and the specialisation of the institutions within which the brokers functioned. These institutions evolved from thematically universal to highly specialise by sector. We observed all these processes and transformations of the brokerage approaches in the entities that were included in the IDI study: Technology Transfer Centre of the University of Lodz, Research and Innovation Centre Pro-Akademia, Foundation for Enterprise Development, Technopark Lodz or Center for Innovation and Technology Transfer of the Medical University of Lodz.

The organisation of the circular economy needs a fundamental change. In a circular economy, it is necessary to seek connections and relationships between sectors. This also implies the need to concentrate but within circular clusters [50]. The logic behind the functioning of a circular cluster is based on the functioning of industrial symbioses and industrial clusters [51].

An innovation broker in this system is essential. While the demand for expertise remains, there is a newfound need for the ability to unite knowledge and partners across different sectors. This fact suggests the need to redefine how an innovation broker is structured and how they function in the circular economy. Due to the considerable acceleration of the dynamics of economic and social processes and the expectation of an immediate response (reaction), the immanent characteristic of the broker today should be, first and foremost, accessibility, or more precisely off-the-shelf. The second predominant characteristic of a broker, which can be inferred from the analysis of trends, preferences and research results, is practical knowledge that can be conveyed in a short and accessible form. In other words, the expectation arises of a broker's non-stop availability, who could handle any number of stakeholders at the same time, without wasting time waiting in line. Thus, other functions such as mentoring or coaching are minimised at this stage.

Accordingly, to the new paradigm of circularity brokerage, the Circular Economy Brokers as an interface are to proactively engage stakeholders and citizens in creating opportunities for circular business and social innovation Figure 2.

The concept of brokerage of circularity addresses four economic megatrends and the Circular Economy Brokers are seen more as a cloud ICT tool than a person dedicated only for circularity development for one or more institutions. In order to achieve high efficiency of circularity development, the geographic area of activity of the circularity broker should be limited to the area determined by the rational use of resources [52,53].

It is a space of circular cluster activity [50,54]. This area should be linked to the region of economic and technological clusters in the traditional understanding of the area of cluster activity [55]. Thus, circularity brokers as a kind of virtual tool will be able to support regional stakeholders and citizens in their activities



for circularity development thanks to:

- easy access to up-to-date, complete and selected information, tailored to the needs of the stakeholder;
- easy transfer, submission and visualization on the platform of individual offers in terms of owned by - products or waste, accessible for sale in the rational and cost-effective territorial coverage;
- access to current market analyses in relation to specific technologies or products from global, European, national and regional perspectives;
- access to the specific cloud platforms and repositories, supported stakeholders in process of circularity development;
- the capability to locate or to find interesting information on regional maps;
- the ability to conduct a self-assessment of the state of implementation of the circularity paradigm in one's own institution using a set of specialized indicators;
- raising awareness and knowledge of circularity on e-learning platforms;
- familiarization with examples of good practices in the development of circularity in various EU regions.

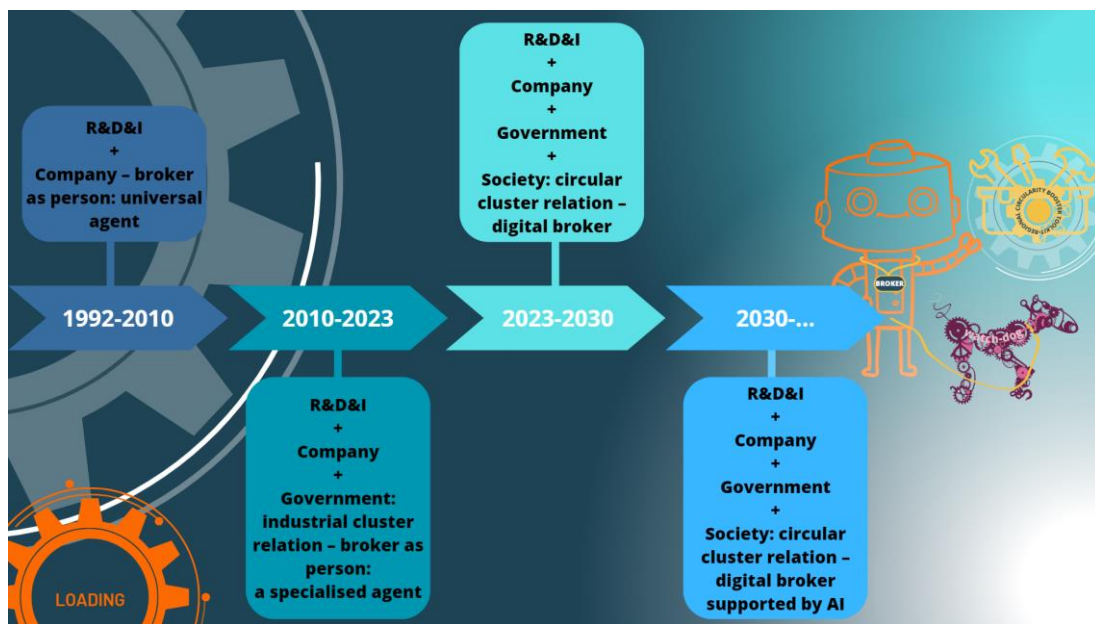


Figure 2. Evolution of the innovation broker function. *Source: Authors.*

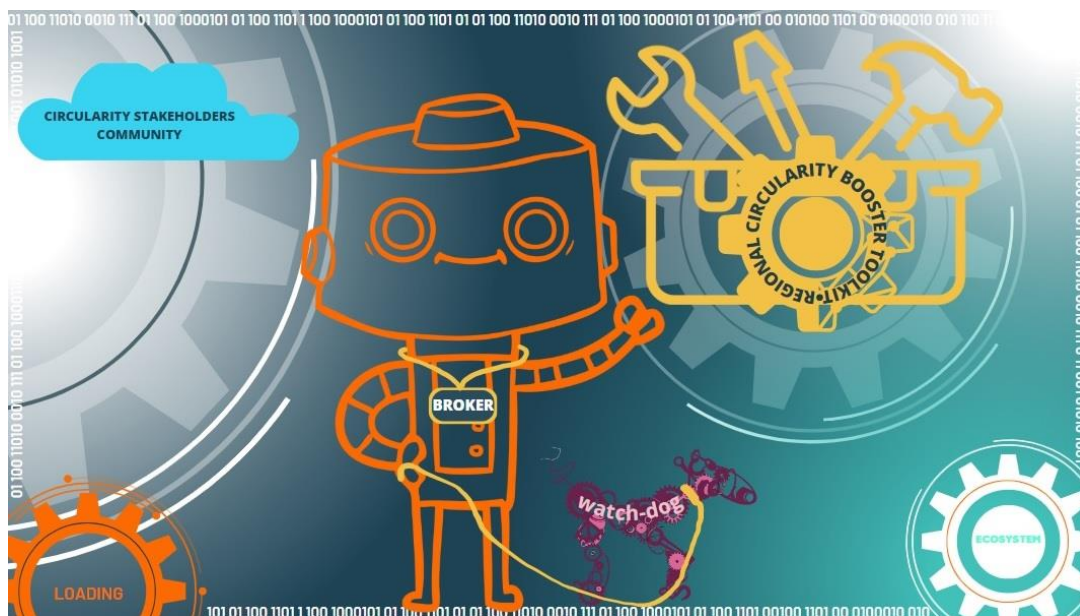


Figure 3. Circularity broker and the watch-dog interfaces among the RCBT. *Source: Authors.*

The regional circularity booster toolkit should provide basic socio-economic and technological information addressing main general questions in terms of circularity development. Among them are selected market analysis, scientific publication in scope of circularity, monitoring system with the circularity self-assessment procedures and for example - the voluntary emission reduction (VER) scheme [56]. Within the H2020 project Frontsh1p [57], there are presumptions of two advanced interfaces elaborated - the Circularity broker and the Circularity watch-dog, facilitating the management of fast data circulation. The mapping tool will enable visualization of a region in a scope interesting for the user, e.g., where the specific waste processing installations are located, where the specific by-products are ready for picking-up, etc.

The Circularity Broker will have his best companion, the circularity watch-dog – an interactive tool for collecting and automatically transferring information to the selected recipients in scope of their identified needs and offers, prepared by circular community stakeholders. Watchdog, which constantly monitors the emergence of new information of a horizontal nature as well, searches for information tailored to the needs of the circularity stakeholder community and (...as a real dog used to do....) "brings" the given information to the Circularity broker. The watch-dog will look after opportunities for the development of local circularity, will track available waste and, more broadly, by-products and by-potential, and after finding it, will announce it loudly. Moreover, it will bring the acquired information to the recipients who are waiting for it. Then, the watch-dog will look after the important data on command from the Circularity broker. In practice, the circularity watch-dog - the interactive tool - will look for, find and immediately transfer data to the identified recipients, guided by a set of appropriate parameters. From technological perspective - the watch-dog should be permanently watching for new resource supply opportunities for companies - materials, waste, by-products and for new, demand for offer of by-products and final products, useful for boosting circular economy development. In particular, the watch-dog interface will follow not only tailored regional recyclers' databases, but also the waste-oriented trade platforms, like e.g., [www.mamodpad.wastemaster.pl](http://www.mamodpad.wastemaster.pl), offering such waste "raw-materials". In the area of social engagement in regional circularity development, circularity broker and its watch-dog, are to compile examples of good practices of local society involvement in environmentally friendly activities. The watch-dog will be permanently analyzing internet portals presenting social initiatives in this area and the circular broker will share them with circularity stakeholder community.

The circularity broker, equipped with regional circularity booster toolkit and with its watchdog, as an interface will perform all the tasks described above. It will be challenging to fix the set of keywords that stakeholders use to search for and enter their own data on platform for solving the specific problems. Simultaneously, another challenge will be an establishing procedure not only to protect users' online privacy, but also to ensure the cyber security of the databases and data processing procedures on the ICT platform, for boosting regional circularity development Figure 3.

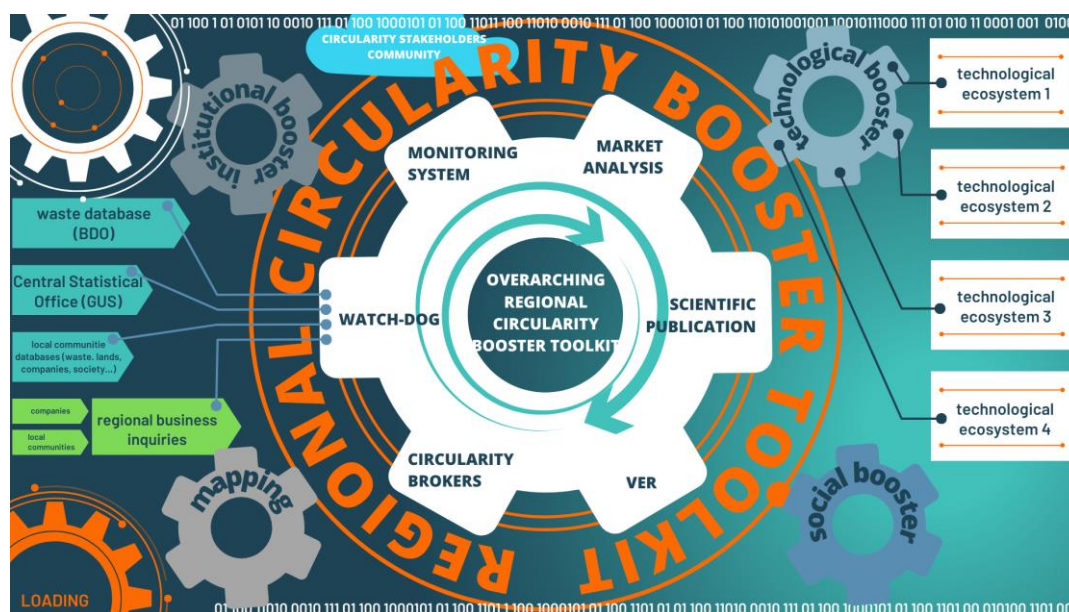


Figure 4. Position of the Circular Economy Broker on the ICT platform for boosting regional circularity development. Source: Authors.

Circularity brokers can implement rewards and incentive systems. By offering virtual badges, discounts, or loyalty points, these platforms may acknowledge and incentivize individuals who actively participate in circular practices such as recycling, sharing, or purchasing sustainable products. These rewards not only encourage continued engagement but also foster a sense of achievement and pride among citizens.

Additionally, digital brokers provide valuable feedback to citizens based on the data collected through their interactions with the platform. This feedback helps individuals refine their circular practices, identify areas for improvement, and make more sustainable choices. By facilitating this feedback loop, circularity brokers empower citizens to continuously learn and grow on their circular journey. While the concept of circularity brokers as virtual tools is relatively new, there are emerging examples and initiatives that demonstrate their potential to impact social aspects. In addition to the RCBT described above, created as part of FRONTS1P project, here are a few already existing platforms that can be showcasing the impact of circularity brokers on social aspects:

- Sharetribe <https://www.sharetribe.com/>: Sharetribe is a platform that enables the creation of sharing economy marketplaces, allowing individuals and communities to share resources, services, and skills. It empowers citizens to become active participants in the circular economy by facilitating peer-to-peer sharing and collaboration. By connecting people and promoting resource sharing, Sharetribe fosters social interaction, community building, and economic empowerment.
- Too Good To Go <https://toogoodtogo.com/>: Too Good To Go is an app-based circularity broker that tackles food waste by connecting consumers with surplus food from restaurants and stores. The app allows users to purchase leftover food at discounted prices, reducing food waste and providing affordable meals. This initiative addresses social issues such as food insecurity, affordability, and access to quality food, while also promoting sustainable consumption and raising awareness about food waste.
- Vinted <https://www.vinted.pl>: Vinted is an online platform that facilitates the exchange of second-hand goods among its users. It enables individuals to sell items they no longer need, promoting the reuse of resources and reducing waste. Vinted's focus on circularity contributes to social aspects by encouraging a culture of sharing, reducing the consumption of new products, and providing affordable access to goods for individuals and communities.
- Open Food Network <https://www.openfoodnetwork.org/>: The Open Food Network is an open-source platform that connects consumers with local food producers and farmers. It enables individuals to source fresh, sustainable, and locally produced food directly from producers. By supporting local farmers and shortening supply chains, the Open Food Network fosters community resilience, promotes fair trade practices, and strengthens social connections between producers and consumers.
- Circularise <https://www.circularise.com/>: Circularise is a block chain-based circularity broker that focuses on improving transparency and traceability in supply chains. It enables companies to share information about the origin, composition, and environmental impact of products while protecting sensitive data. By promoting transparency, circularise enhances social aspects such as trust, consumer confidence, and accountability, allowing individuals to make informed purchasing decisions.

These examples highlight how circularity brokers, in the form of virtual tools and platforms, can contribute to social aspects by fostering collaboration, resource sharing, and access to affordable goods, transparency, and community building. As the circular economy continues to evolve, it is expected that more innovative circularity brokers will emerge, further influencing social aspects in positive ways.

The added value for the local and regional development of the proposed circularity brokering paradigm is access to appropriate, dedicated/ tailored and up-to-date information for the various stakeholders of circularity, e.g., companies, local administration, social cooperatives as well as non-governmental organizations, households and individuals. The Circular Economy Broker as an interface on cloud platform will allow all stakeholders of circularity at the regional level to create opportunities for circular business and social innovation. For local administration, a circularity broker will contribute to creating a beneficial environment for circular economy growth, will facilitate the search for good practices or patterns for how to initiate and support such model of regional development.

The preparation of a circularity broker in the form of an interface on cloud platforms is a prerequisite for the involvement of artificial intelligence in the future. The preparation of a circularity broker in the form of an interface on cloud platforms is a prerequisite for the involvement of artificial intelligence in the future. Artificial intelligence is an opportunity for a widespread, and smooth, transformation towards a circular

economy. AI as a tool to accelerate the transition [58–61]. We already know that AI involvement will be important in areas such as asset management, data and information management, data security, document management, communication management, training and advisory services, market analysis and reporting, design management, infrastructure management and other.

### **Impact**

The concept of digital broker, as analyzing in this article, draws inspiration from mega trends especially sharing economy and through this sheds light on the social aspects involved [18]. Circularity brokers, as virtual tools, can play a crucial role in supporting citizens in transforming into sustainable society. Digital brokers as digital tools offer a range of valuable features and services that empower individuals to actively participate in CE [62]. Firstly, circularity brokers can act as gateways, facilitating citizens' access to various circular services and opportunities. These platforms connect individuals with sharing platforms, repair services, second-hand marketplaces, and sustainable product alternatives. By aggregating and showcasing these options, circularity brokers simplify the process of finding and accessing circular solutions that align with citizens' needs and values. Secondly, they provide features such as online communities, forums, and social networking tools, enabling citizens to connect with like-minded individuals, share knowledge, and collaborate on circular initiatives. Digital brokers also offer measurement tools that allow citizens to track and assess their circular practices. These tools monitor metrics such as waste reduction, energy savings, material reuse, and carbon footprint. By visualizing their progress, citizens gain a deeper understanding of the impact of their actions, which in turn motivates them to further improve their circularity efforts.

### **Conclusions**

The organisation of the circular economy needs a fundamental change of the role of brokerage as a bridge under the gaps between business and industry and academia worlds. The research conclusions in the article confirm that traditional innovation brokers are not effective enough. The brokerage formula is unadjusted to present - day economic, technological and, above all, information challenges, thus the twilight of traditional brokerage of innovation and circularity development is observed. Brokers today should focus on transitioning to a circular economy. This transition requires significant changes across many sectors and stakeholders. The new paradigm of circular brokers activities involves rethinking production processes, implementing sustainable waste management practices, fostering collaboration among businesses, policymakers, and consumers, and promoting innovative technologies and business models. Modern circularity brokers act as orchestrators within the ecosystem of circular economy, actively participating in processes of change and striving to establish alliances and collaborations among diverse stakeholders. The predominant characteristic of a broker, which can be inferred from the analysis of trends, preferences and research results (IDIs), is comprehensive and interdisciplinary but practical knowledge which should be conveyed in a short and accessible form just on time and just on exact demand. No later, no earlier, no more and no less. The demand of circularity brokers' non-stop availability and handling any number of stakeholders at the same time, can be addressed only by the IT interfaces, dedicated and tailored to circular development stakeholders needs.

In conclusion, as a virtual instrument, circularity brokers can foster the actions of both regional stakeholders and citizens involved in the promotion of circularity development. This is achieved by offering straightforward access to timely, comprehensive, and curated data. Furthermore, these brokers facilitate the seamless transfer, submission, and display of individual offerings, which may pertain to personally owned by-products or waste. These assets are immediately available for purchase, and this facilitated commerce happens within a territorially bounded area defined by efficient and reasoned use of resources on cloud-based platforms. The IT circularity brokers can facilitate the access to current market analyses in relation to specific technologies or products from global, European, national and regional perspectives. Summering: the circularity brokers, as virtual tools, can play a crucial role in supporting not only industry in transition from linear to circular economy development, but also citizens in transforming into sustainable society.

### **Conflict of interest**

There are no conflicts to declare.

### **Acknowledgments**

The research was conducted within the project “FRONSTH1P: A FRONTrunner approach to Systemic circular, Holistic & Inclusive solutions for a new Paradigm of territorial circular economy”, funded from the European Union's Horizon2020 research and innovation programme under grant agreement No. 101037031.

## References

- [1] D.J. Watts, Networks, dynamics, and the small-world phenomenon 1, *Am. J. Sociol.* 105 (1999) 493–527. <https://doi.org/10.1086/210318>.
- [2] Mark S. Granovetter, The Strength of Weak Ties, *Am. J. Sociol.* 78 (1973) 1360–1380.
- [3] R.S. Burt, Structural Holes and Good Ideas, *Am. J. Sociol.* 110 (2004) 349–399. <https://doi.org/10.1086/421787>.
- [4] E.L. Lingo, S. O’Mahony, Nexus work: Brokerage on creative projects, *Adm. Sci. Q.* 55 (2010) 47–81. <https://doi.org/10.2189/asqu.2010.55.1.47>.
- [5] J. Howells, Intermediation and the role of intermediaries in innovation, *Res. Policy.* 35 (2006) 715–728. <https://doi.org/10.1016/j.respol.2006.03.005>.
- [6] European Commission, Guidance on Innovation Procurement, 2021.
- [7] P. Kumar, R.K. Singh, V. Kumar, Managing supply chains for sustainable operations in the era of industry 4.0 and circular economy: Analysis of barriers, *Resour. Conserv. Recycl.* 164 (2021) 105215. <https://doi.org/10.1016/j.resconrec.2020.105215>.
- [8] I. Cosme, R. Santos, D.W. O’Neill, Assessing the degrowth discourse: A review and analysis of academic degrowth policy proposals, *J. Clean. Prod.* 149 (2017) 321–334. <https://doi.org/10.1016/j.jclepro.2017.02.016>.
- [9] T. Vadén, V. Lähde, A. Majava, P. Järvensivu, T. Toivanen, E. Hakala, J.T. Eronen, Decoupling for ecological sustainability: A categorisation and review of research literature, *Environ. Sci. Policy.* 112 (2020) 236–244. <https://doi.org/10.1016/j.envsci.2020.06.016>.
- [10] L. Georgeson, M. Maslin, M. Poessinouw, The global green economy: a review of concepts, definitions, measurement methodologies and their interactions, *Geo Geogr. Environ.* 4 (2017) e00036. <https://doi.org/10.1002/geo2.36>.
- [11] European Parliament, Circular economy: definition, importance and benefits, (2022). <https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits>.
- [12] ISM Waste & Recycling, What is the Waste Hierarchy?, (2022).
- [13] F. Bartolacci, R. Cerqueti, A. Paolini, M. Soverchia, An economic efficiency indicator for assessing income opportunities in sustainable waste management, *Environ. Impact Assess. Rev.* 78 (2019) 106279. <https://doi.org/10.1016/j.eiar.2019.05.001>.
- [14] M. Bianchi, M. Cordella, Does circular economy mitigate the extraction of natural resources? Empirical evidence based on analysis of 28 European economies over the past decade, *Ecol. Econ.* 203 (2023) 107607. <https://doi.org/10.1016/j.ecolecon.2022.107607>.
- [15] S. Böhm, C.H. Ho, H. Holmes, C. Manolchev, M. Rödl, W. Spekkink, 14 Circular society activism: De Gruyter, (2023) 241–260.
- [16] PeoplePerHour, The Evolution of the On-Demand Economy, 2015.
- [17] J. Frankenfield, Collaborative economy, Investopedia. (2021). <https://www.investopedia.com/terms/c/collaborative-economy.asp>.
- [18] K. Frenken, J. Schor, Putting the sharing economy into perspective, *Environ. Innov. Soc. Transitions.* 23 (2017) 3–10. <https://doi.org/10.1016/j.eist.2017.01.003>.
- [19] G. Petropoulos, An economic review of the collaborative economy, *Policy Contrib.* (2017) 1–17.
- [20] H. Bruyninckx, Summer 2022: Living in a state of multiple crises, *Eur. Environ. Agency.* (2022).
- [21] PwC, The sharing economy : how will it disrupt your business ? Megatrends : the collisions August 2014 The Sharing Economy : Key Messages, London, 2014.
- [22] V. Laury, Collaborative consumption, (2014).
- [23] J. Hamari, M. Sjöklint, A. Ukkonen, The sharing economy: Why people participate in collaborative consumption, *J. Assoc. Inf. Sci. Technol.* 67 (2016) 2047–2059. <https://doi.org/10.1002/asi.23552>.
- [24] A. Menor-Campos, M. de los B. García-Moreno, T. López-Guzmán, A. Hidalgo-Fernández, Effects of collaborative economy: A reflection, *Soc. Sci.* 8 (2019) 142. <https://doi.org/10.3390/socsci8050142>.
- [25] S. Carlin, K. Curran, Cloud Computing Technologies, *Int. J. Cloud Comput. Serv. Sci.* 1 (2012). <https://doi.org/10.11591/closer.v1i2.486>.
- [26] R. Kurzweil, Technology and the New, Improved You, *Wall Str. J.* (2014).
- [27] A. Pluta-Zaremba, A. Szelągowska, Transformation of the economy. Towards era 5.0, in: *Econ. Sustain. Transform.*, Routledge, London, 2021: pp. 12–56. <https://doi.org/10.4324/9781003219958-3>.
- [28] E. Kochańska, Language of benefits for digital sharing of knowledge on the open access interactive platform, *Acta Innov.* 20 (2016) 31–42.
- [29] P.D. Gluckman, A. Bardsley, M. Kaiser, Brokerage at the science–policy interface: from conceptual

- framework to practical guidance, *Humanit. Soc. Sci. Commun.* 8 (2021) 84. <https://doi.org/10.1057/s41599-021-00756-3>.
- [30] A. Di Vaio, S. Hasan, R. Palladino, R. Hassan, The transition towards circular economy and waste within accounting and accountability models: a systematic literature review and conceptual framework, *Environ. Dev. Sustain.* 25 (2023) 734–810. <https://doi.org/10.1007/s10668-021-02078-5>.
- [31] A. Alcalde-Calonge, F.J. Sáez-Martínez, P. Ruiz-Palomino, Evolution of research on circular economy and related trends and topics. A thirteen-year review, *Ecol. Inform.* 70 (2022) 101716. <https://doi.org/10.1016/j.ecoinf.2022.101716>.
- [32] V. Durgekar, Towards Sustainable Waste Management Through Technological Innovations, Effective Policy, Supply Chain Integration & Participation, *Procedia Environ. Sci.* 35 (2016) 140–149. <https://doi.org/10.1016/j.proenv.2016.07.061>.
- [33] C. Fogarassy, D. Finger, Theoretical and practical approaches of circular economy for business models and technological solutions, *Resources.* 9 (2020) 1–9. <https://doi.org/10.3390/resources9060076>.
- [34] M. Lewandowski, Designing the business models for circular economy-towards the conceptual framework, *Sustain.* 8 (2016) 43. <https://doi.org/10.3390/su8010043>.
- [35] M. Lieder, A. Rashid, Towards circular economy implementation: A comprehensive review in context of manufacturing industry, *J. Clean. Prod.* 115 (2016) 36–51. <https://doi.org/10.1016/j.jclepro.2015.12.042>.
- [36] A. Upadhyay, K.C. Balodi, F. Naz, M. Di Nardo, L. Jraisat, Implementing industry 4.0 in the manufacturing sector: Circular economy as a societal solution, *Comput. Ind. Eng.* 177 (2023) 109072. <https://doi.org/10.1016/j.cie.2023.109072>.
- [37] M. Agyemang, S. Kusi-Sarpong, S.A. Khan, V. Mani, S.T. Rehman, H. Kusi-Sarpong, Drivers and barriers to circular economy implementation: An explorative study in Pakistan’s automobile industry, *Manag. Decis.* 57 (2019) 971–994. <https://doi.org/10.1108/MD-11-2018-1178>.
- [38] J.M. Cramer, The function of transition brokers in the regional governance of implementing circular economy - A comparative case study of six dutch regions, *Sustain.* 12 (2020) 5015. <https://doi.org/10.3390/su12125015>.
- [39] W. McDowall, Y. Geng, B. Huang, E. Barteková, R. Bleischwitz, S. Türkeli, R. Kemp, T. Doménech, Circular Economy Policies in China and Europe, *J. Ind. Ecol.* 21 (2017) 651–661. <https://doi.org/10.1111/jiec.12597>.
- [40] A. Padilla-Rivera, S. Russo-Garrido, N. Merveille, Addressing the social aspects of a circular economy: A systematic literature review, *Sustain.* 12 (2020) 7912. <https://doi.org/10.3390/SU12197912>.
- [41] Z. Liu, D. Schraven, M. de Jong, M. Hertogh, The societal strength of transition: a critical review of the circular economy through the lens of inclusion, *Int. J. Sustain. Dev. World Ecol.* (2023) 1–24. <https://doi.org/10.1080/13504509.2023.2208547>.
- [42] A.S. Tumilar, D. Milani, Z. Cohn, N. Florin, A. Abbas, A modelling framework for the conceptual design of low-emission eco-industrial parks in the circular economy: A case for algae-centered business consortia, *Water (Switzerland)*. 13 (2021) 69. <https://doi.org/10.3390/w13010069>.
- [43] A. Angelis-Dimakis, G. Arampatzis, A. Alexopoulos, A. Pantazopoulos, I. Vyrides, N. Chourdakis, V. Angelis, Waste Management and the Circular Economy in Cyprus—The Case of the SWAN Project, *Environ. - MDPI.* 9 (2022) 16. <https://doi.org/10.3390/environments9020016>.
- [44] K.A. Patton, L. D., & Renn, Student Development in College: Theory, Research, and Practice., Jossey-Bass, 2016.
- [45] A. Parzonko, S. Wawrzyniak, K. Krzyżanowska, the Role of the Innovation Broker in the Formation of Eip-Agri Operational Groups, *Ann. Polish Assoc. Agric. Agribus. Econ.* XXIV (2022) 194–208. <https://doi.org/10.5604/01.3001.0015.7252>.
- [46] D. Obstfeld, Social Networks, the Tertius Iungens Orientation, and Involvement in Innovation., 2005.
- [47] K.C. Kellogg, Brokerage Professions and Implementing Reform in an Age of Experts, *Am. Sociol. Rev.* 79 (2014) 912–941. <https://doi.org/10.1177/0003122414544734>.
- [48] R. Huising, S.S. Silbey, Governing the gap: Forging safe science through relational regulation, *Regul. Gov.* 5 (2011) 14–42. <https://doi.org/10.1111/j.1748-5991.2010.01100.x>.
- [49] Ö. Öz, The Competitive Advantage of Nations, *Harvard Business Review*, 2019. <https://doi.org/10.4324/9780429439087-1>.
- [50] Z. Przygodzki, et.al., Policy Framework and Market analysis, 2023.
- [51] M.R. Chertow, Industrial symbiosis: Literature and taxonomy, *Annu. Rev. Energy Environ.* 25 (2000) 313–337. <https://doi.org/10.1146/annurev.energy.25.1.313>.
- [52] A.M. Lis, M. Mackiewicz, The implementation of green transformation through clusters, *Ecol. Econ.* 209

- (2023) 107842. <https://doi.org/10.1016/j.ecolecon.2023.107842>.
- [53] E. Kochańska, R.M. Łukasik, M. Dzikuć, New circular challenges in the development of take-away food packaging in the covid-19 period, *Energies*. 14 (2021) 4705. <https://doi.org/10.3390/en14154705>.
- [54] E. Kochanska, et.al., *Regional Circularity Booster Toolkit*, 2023.
- [55] A. Zandiatashbar, S. Hamidi, Exploring the microgeography and typology of U.S. high-tech clusters, *Cities*. 131 (2022) 103973. <https://doi.org/10.1016/j.cities.2022.103973>.
- [56] The World Bank, *Carbon Pricing 2021 State and Trends of Carbon Pricing 2021*, Washington DC (USA), 2021. <https://doi.org/10.1596/978-1-4648-1586-7>.
- [57] The Frontsh1p, *A FRONTrunner approach to Systemic circular, Holistic & Inclusive solutions for a New Paradigm of territorial circular economy*, (2021).
- [58] Ellen MacArthur Foundation, *Artificial intelligence and the circular economy - AI as a tool to accelerate the transition*, (2019).
- [59] Chui Michael, et.al, *Notes from the AI frontier applying AI for social good*, 2018.
- [60] H. Roberts, J. Zhang, B. Bariach, J. Cows, B. Gilbert, P. Juneja, A. Tsamados, M. Ziosi, M. Taddeo, L. Floridi, *Artificial intelligence in support of the circular economy: ethical considerations and a path forward*, *AI Soc.* (2022). <https://doi.org/10.1007/s00146-022-01596-8>.
- [61] M.S. Pathan, E. Richardson, E. Galvan, P. Mooney, *The Role of Artificial Intelligence within Circular Economy Activities—A View from Ireland*, *Sustainability*. 15 (2023) 9451. <https://doi.org/10.3390/su15129451>.
- [62] F. Ciulli, A. Kolk, S. Boe-Lillegraven, *Circularity Brokers: Digital Platform Organizations and Waste Recovery in Food Supply Chains*, *J. Bus. Ethics*. 167 (2020) 299–331. <https://doi.org/10.1007/s10551-019-04160-5>.