ENTREPRENEURSHIP AND SUSTAINABILITY ISSUES
ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2024 Volume 11 Number 3 (March)
http://doi.org/10.9770/jesi.2024.11.3(29)

Publisher
http://jssidoi.org/esc/home

REVIEW OF CHALLENGES TO TRANSITION TOWARDS CIRCULAR ECONOMY

Olga Lingaitienė [1], Aurelija Burinskienė [2], Valentas Gružauskas [3]

[1,2,3] Business Management Faculty, Vilnius Gediminas Technical University, Saulėtekio av. 11, LT-10223 Vilnius, Lithuania

E-mails:[1] olga.lingaitiene@vilniustech.lt; [2] aurelija.burinskiene@vilniustech.lt; [3] valentas.gružauskas@vilniustech.lt

Received 15 November 2023; accepted 13 March 2024; published 30 March 2024

Abstract. The growing volume of waste worldwide is driving us to search for solutions to recycle waste and reduce material consumption. It is necessary to create models that stop the deterioration of the environmental condition and offer a transition to a more efficient economic system where resources are less intensively used. The EU needs to ensure the transition to a sustainable circular economy (CE), which provides for waste recycling and preserves the value of natural resources, raw materials, and goods produced in the market for as long as possible. A more efficient economic system would contribute significantly to the United Nations (UN) Sustainable Development (SD) Agenda targeted until 2030. This topic has still to be addressed in the literature, so we aim to reduce the research gaps in the publications with this article. The authors selected and analysed the variables that mainly influenced waste recycling, which is part of CE processes. The paper assessed the relationship between resource productivity and waste recycling variables; a Vector Error Correction Model was used. The results allowed us to provide novel insights concerning CE challenges.

Keywords: circular economy; waste recycle; reduce; consuption; business process

Reference to this paper should be made as follows: Lingaitienė, O., Burinskienė, A., Gružauskas, V 2024. Review of challenges to transition towards circular economy. *Entrepreneurship and Sustainability Issues*, 11(3), 423-436. http://doi.org/10.9770/jesi.2024.11.3(29)

JEL Classifications: M21

1. Introduction

Well-known environmental problems such as resource depletion and overexploitation, water, air, and soil pollution, and biodiversity loss are increasingly threatening the earth and call for an urgent shift towards more sustainable socio-technical systems (Adami & Schiavon, 2021; Yang et al., 2023). CE processes are being used to solve climate change and other global issues such as pollution, waste, biodiversity losses, and the decoupling of economic activity from using scarce natural resources. Global industrialisation and over-reliance on non-renewable sources of energy affected the increase of solid waste and climate changes, which is why the European Green Deal, the number of proposed means by the European Commission, aims to reshape the EU's climate, energy, transport, and taxation policies, and to pursue a CE in all sectors, to achieve a 55% decarbonisation of the EU's climate, energy, transport, and tax policy and to achieve a carbon neutral economy by 2050.

The terms "circular economy" and "sustainability" are broad, with no single definition in the literature, and which attracted the interest of scientists from different disciplines (environmentalists, economists, engineers, sociologists, and others), global organisations, businesses, policymakers, whole private sector, consumers and individuals (Nobre & Tavares, 2021; Geissdoerfer et al., 2017; Aithal & Aithal, 2023). This broadness creates room for interpretation, misinterpretation, and misuse of the term greenwashing and the risk of damage to the landscape. Organisations are moving towards a sustainable and resilient economy by implementing circular principles, generating economic value, and reducing environmental impacts. However, it is common for organisations to adapt and shape CE definitions and paradigms according to established processes within the company rather than changing their practices (Kirchher et al., 2017).

The EU governments must coordinate the transformation of the CE and processes toward resource efficiency and greater material circularity. Although average resource productivity has increased by around 40% since 2000, more is needed to compensate for the increase in material use (OECD, 2019). The CE reveals design-based principles, eliminating the negative impact of economic activities that harm the health of the population and natural systems at the design stage, reducing the waste amount and pollution level, circulating products and raw materials, and creating maximum value. EU countries envision progressing towards sustainable CE and resource efficiency. Good practices should be identified to pursue better policies for implementing the CE.

2. Complex management of circular business processes

As the world moves faster and faster into the era of the CE, governments in the EU governments are playing essential roles in driving higher resource efficiency and material circularity. The EU countries must use resources efficiently. This requires complex management, understood as various forms and practice elements needed to implement business changes associated with increasing resource use efficiency successfully.

Recycling is gaining increasing attention in almost all areas of life. There is a clear need to develop models to halt environmental degradation and propose a shift towards a more efficient economic system with less intensive resource use. In the EU, it is essential to ensure the change to a sustainable CE, which would extend for the most significant possible reduction of waste volumes while at the same time preserving the value of natural resources, raw materials, and produced products in the market longer. Recyclable wastes can reduce the need for resource extraction as reusable material is collected seeking to reuse them applying the manufacturing activities. The need to extract primary resources decreases if the lower demand is for raw materials, resulting in less waste generation, correspondingly reducing harmful effects on the natural environment and promoting the conservation of nature.

Researchers and employees emphasised the application of new business models seeking to accelerate the transition from "linear" to "circular" solutions. International corporations promoting business models that follow circularity are cyclical and want the first to break up the unidirectional linear economic system (Schaltegger et al., 2016). One fundamental question still needs to be answered in the scientific literature: how could companies move toward circularity successfully? CE research has sought answers to such questions at the firm level. Such studies focus primarily on companies' motivations for adopting the creation of circular value approaches together with propositions dedicated to motivational aspects and possibilities, e.g., increasing competitiveness through increased efficiency of cost due to lower energy demand and inputs of natural resources, creating the environment to attract sustainable segments of the customer (Gusmerotti et al., 2023) and financial, organisational, market and institutional risks and barriers to integrating CE principles into everyday business practices. Second, existing research on the CE explored the contours of new models for business by describing their constituent elements. The prevailing view is that firms' chains construct stable social systems but incorporate dynamism.

3. Resource productivity in the circular economy

The CE is an economic system that seeks to use resources efficiently, avoiding waste and accumulation with environmental protection and sustainable development (Sverko Grdic el. al., 2020). It is often used in sustainable development (SD), seeking to reconcile economic growth while applying environmental protection (Belmonte-Ureña et al., 2021). Kirchher et al., 2017 examined 114 definitions of CE. They found that CE is generally portrayed as a combination of reduction, reuse, and recycling activities, but there is little clear linkage between CE and sustainable development. The CE goals are often associated with economic prosperity in line with the environment's quality, with little emphasis on its impact on socioeconomic justice for future

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2024 Volume 11 Number 3 (March)
http://doi.org/10.9770/jesi.2024.11.3(29)

generations. According to Mavi and Mavi (2019), by combining climate changes and global warming processes and protecting natural resources, the CE seeks sustainable development through renewable energy and waste management, defining the development of the economy and minimising the non-undesirable impacts on the environment. Moraga et al. (2022) observed that despite multiple and not always precise definitions, the CE does translate into concrete action plans based on specific indicators, and they proposed a classification system that categorises indicators into CE strategies and measurement scopes. The authors noted that the focus is on material conservation through recycling strategies. Cui and Zhang (2022) noted that the CE significantly impacts decarbonisation. The authors analysed the carbon impact of the CE on productivity by assessing the effect of the CE on decarbonisation through a framework of indicators along several dimensions, such as resource efficiency and economic benefits. The development of the CE has a positive impact on carbon productivity. Ding et al. (2020) described the environmental problems of China as a significant industrial-producing country consuming vast amounts of resources, emitting considerable amounts of pollutants, with correspondingly high and persistent land degradation, air pollution and quality of water degradation, and the loss of species, with the pressures of high resource consumption and high pollution emissions Malmquist productivity indexes needed to model dynamic performance changes. Moraga et al. (2022) argued that resource efficiency indicators can measure materials' life-cycle efficiency and are defined as benefits, not burdens. The authors found that the industrial CE maximises economic benefits by reducing negative environmental impact, redoing disposal, efficient waste management, and using renewable sources.

According to the European Commission, the CE monitoring system includes new indicators of material use estimates and resource efficiency, which measure the efficiency of using materials in the EU production and consumption system. There is also another group of indicators of waste prevention. These indicators are elements of a circular and zero economy that measure the contribution of the CE. The productivity resource of the CE is an essential indicator of how efficiently natural resources are used and how well waste is managed. Factors affecting the productivity indicator are distinguished and presented in Table 1.

Table 1. Factors affecting CE productivity

Factors	Description	References
Efficient use of resources	The CE seeks to make the most of resources, saving them and reducing losses. These include energy efficiency, water saving, material recycling, etc.	Moraga et. al., 2022; Lingaitienė & Burinskienė, 2021; Burinskienė et al. 2022; Yang et. Al, 2023; Figge & Thorpe, 2023; Lu et al., 2024; Xijie et al., 2023; Munaro & Tavares, 2023; Burke et al., 2023; Mostaghimi & Behnamian, 2023
Waste minimisation	The CE seeks to see it as a source of resources. This means that waste is minimised, and the recovered waste is recycled and converted into innovative forms of production.	Kirchherr et al., 2023; Lingaitienė et al. 2022; Burinskienė et al. 2022; Yang et. al, 2023; Figge & Thorpe, 2023; Lu et al., 2024; Xijie et al., 2023; Munaro & Tavares, 2023; Burke et al., 2023; Mostaghimi & Behnamian, 2023; Katakojwala et. al., 2023; Voukkali et al., 2023; Ruiz et al., 2020; Mintz et al. 2019
Cyclicality	The CE promotes the cyclicality of resources; that is, resources are used to be reused without significant losses. Such could be achieved by applying repair and recycling.	Moraga et. al., 2022; Xijie et al., 2023; Burke et al., 2023; Kirchherr et al., 2023; Voukkali et al., 2023; Den Hollander et al., 2017
Innovation and technology	The CE drives innovation and technologies that allow for the use of resources more efficiently and minimise the negative impacts on nature.	Sehnem et al., 2022; Yang et. al, 2023; Lu et al., 2024; Xijie et al., 2023; Munaro & Tavares, 2023; Burke et al., 2023; Mostaghimi & Behnamian, 2023; Kirchherr et al., 2023; Voukkali et al., 2023
Cooperation and partnership	In the context of a CE, cooperation between businesses, public authorities, non-governmental organisations, and society is essential.	Munaro & Tavares, 2023; Mostaghimi & Behnamian, 2023; Kirchherr et al., 2023; Voukkali et al., 2023
Socioeconomic responsibility	Companies and organisations must take responsibility for their activities and impacts on the environment and society. This may include commitments to sustainable production, responsible supply chains, and social support projects.	Lingaitienė et al., 2022; Burinskienė et al., 2022; Yang et. al, 2023; Lu et al., 2024; Xijie et al., 2023; Munaro & Tavares, 2023; Burke et al., 2023; Kirchherr et al., 2023; Voukkali et al., 2023

Resource efficiency and the CE are essential in environmental and economic protection. Resource efficiency reduces dependence on natural resources, playing a vital role in the economy and protecting the world, thus benefiting in the long term (Moraga et al., 2022; Burinskienė et al., 2022).

Resource productivity in the CE is a complex and multidimensional indicator that values economic profit and social and environmental impacts. A successful CE seeks to reconcile these aspects for long-term sustainability and prosperity.

All waste poses indirect risks. Improper disposal of waste in landfills, if not properly equipped, can contaminate drinking, surface, and groundwater (Figge & Thorpe, 2023; Petrariu et al., 2022: Lingaitienė et al., 2022).

Climate change also risks landfills built close to water (Yang et al., 2023; Xijie et al., 2023; Lu et al., 2024). Waste incineration is practised worldwide following strict public health and environmental standards, but inadequate incineration or the burning of unsuitable materials results in the release of ash residues and other harmful substances and carcinogens into the air, with a wide range of adverse health effects (Kirchherr et al., 2023; Burke et al., 2023; Mostaghimi & Behnamian, 2023).

The authors describe CE's contribution to SD and promote responsible resource use. The literature often describes indicators regarding their life-cycle impact on environmental, social, or economic aspects (Moraga et al., 2022; Kirchherr et al., 2023; Xijie et al., 2023). Examining the basic principles of the CE, Skene (2018) argued that nature operates using short cycles rather than longer lifespans and that nature's economy works as an open system rather than a closed one.

Suchek et al. (2021) state that it is estimated that the world will have 2.59 bln. tonnes of waste annually around 2030; by 2050, the amount generated globally will grow to as much as 3.40 billion tonnes. Geissdoerfer et al., 2017 argue that CE is the solution which acts as a system, focusing on reducing inputs of natural resources and wastes, slowing down CO2 and demand for energy, and closing and straightening the material's chain. Suchek et al. (2021) and Prieto-Sandoval et al. (2019) emphasise the link between CE and environmental innovations in case society reuses. According to the authors, innovative business models have strong links with product innovation for circularity, with strategies based on new business models and product development, which are slowing down, aiming to close the circulation of materials.

The SD Goals follow innovative transformations that reduce environmental impacts in different areas, emphasising the importance of cooperation in all activities in the transition towards sustainable development (Munaro & Tavares, 2023; Mostaghimi & Behnamian, 2023; Kirchherr et al., 2023).

4. Practices for reducing different types of waste

Salmenperä et al. (2021) point out that the role of management in the CE is to promote the preservation of the value of natural resources in the cycles by recycling them, reducing wastes by strengthening the dialogue and cooperation of the key actors, ensuring the sharing of waste-related data and by reinforcing the economic benefits of the CE helping to reduce greenhouse gas (GHG) emission. 3R (reduce, reuse, and recycle) initiatives help reduce GHG emissions, implement sustainable resource applications, and promote resource efficiency (Sakai et al., 2017; Ruiz et al., 2020). Patwa et al. (2021) found that the 3R practice to extend the product's life and prevent resource wastage is in line with the objectives of the CE and contributes to the ecological balance. The manufacturing energy from wastes, the application of renewed energy, and the efficient usage of resources help to reduce waste and increase economic efficiency in the CE.

Di Foggia and Beccarello (2021) carried out an empirical analysis based on an econometric approach and proposed effective waste management at the national level. The authors pointed out that waste management technologies designed to reduce waste disposal in landfills are essential in achieving the goals of the CE. The authors also assessed the impact of such a system in line with the cost of waste management. They described how much the use of landfills would reduce the mechanical-biological treatment of waste by increasing the capacity for obtaining energy from waste, which could positively impact the environment and save waste management expenses at the treatment and other disposal stages. According to Sherwood (2020), the CE is an international collaboration between all stakeholders committed to eliminating waste without value. Reducing waste and limiting the use of scarce resources is part of sustainability and ensuring circularity. It is to be seen

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2024 Volume 11 Number 3 (March)
http://doi.org/10.9770/jesi.2024.11.3(29)

as a tool to promote positive action, building on the Renewable Energy Directive, the Waste Directive, and the CE Initiative, which defines waste limit values.

The practices of reducing different types of waste include various methods and strategies for reducing waste and saving the environment. Standard waste reduction practices are presented in Table 2.

Table 2. Reducing methods specific to types of waste

Type of waste-reducing	Reducing methods	Description	References
Waste prevention	Product design	Companies can develop products with long service lives, which are easily recycled and use less packaging.	Den Hollander et al., 2017; Sakai et al., 2017; Parajuly et al., 2020; Burke et al., 2023
Promotion of reuse	Deposit system	Stores can be equipped with deposit systems that allow customers to return and use the packages again.	Linderhof et al. 2019; Coelho et al. 2020; Cottafava et al., 2021; Balwada et al., 2021; Du Rietz, 2023
Other recovery	Incineration	Waste that cannot be recycled may be incinerated and incorporated into the production of energy, helping get electricity and heat, thereby preserving other natural resources to reduce waste.	Adami & Schiavon, 2021; Bisinella et al., 2021; Kirchherr et al., 2023; Yang et al., 2023; Munaro & Tavares, 2023; Lingaitienė et al., 2022; Istrate et al., 2023
Disposal	Landfill	Waste disposal in landfills is less desirable than waste prevention, reuse, and recycling. Still, sometimes squatters can be necessary when there are no other options or if a particular waste is hazardous and cannot be recycled.	Mukherjee et al., 2021; Siddiqua et. al., 2022
Waste recycling	Waste sort and separate	Businesses and households can use waste sorting systems to distinguish between recycling plastic, glass, metal, and carton materials.	Serranti & Bonifazi, 2019; Pluskal, et al., 2021; Feil & Pretz, 2020; Lange, 2021; da Silva & Wiebeck, 2020; Lim et. al., 2022
	Collaboration with recycling plants	Companies can work with local recycling plants to recycle useful materials and reduce waste.	Serranti & Bonifazi, 2019; Pluskal, et al., 2021
Stimulation of biodegradation	Using composting systems	Households and communities can use composting systems to biodegrade organic waste and produce natural fertiliser.	Castro-Aguirre et al., 2017; Ajmal et al., 2020; Kalita et al., 2020; Soto-Paz et al., 2021
	Reducing food waste	Restaurants and grocery stores could apply strategies to help reduce food waste by promoting food packaging and recycling.	Borrello et al., 2017; Talwar et al., 2023
Waste education	Educational campaigns	Governments and non-governmental organisations can conduct educational campaigns to inform the public about waste management techniques and promote environmentally friendly behaviour.	Abbasi et al., 2020; Soma et al., 2020; Szakos et al., 2021; Yusuf & Fajri, 2022
	Training and seminars	Companies can organise employee training and waste prevention, sorting, and recycling seminars.	Khandelwal et al., 2019; Magriotis et al., 2021

Preventing waste is the first and most effective way to reduce the amount of waste (Den Hollander et al., 2017). Concerning waste prevention, different authors highlight the role of product design, proposing to distinguish between eco-design and circular product design, redefining the product life cycle (Sakai et al., 2017; Parajuly et al., 2020; Burke et al., 2023). Many products, such as glass bottles, different paper, plastic packaging, shopping bags, or other waste, can be reused. Promoting reuse can reduce the need for single-use products (Balwada et al., 2021). The Circular Solution scheme, which promotes reuse, involves the involvement of circular denominators who take part in a deposit incentive scheme, paying a deposit when they buy beverages, which is then refunded to them if they recycle the beverage containers (Linderhof et al. 2019; Coelho et al., 2020; Cottafava et al., 2021; Du Rietz, 2023).

In the life cycle assessment of waste, scientists are looking for the optimal disposal or recycling solutions for each type of waste (Siddiqua et al., 2022). Waste recycling transforms old products or materials into new goods or raw materials. It involves processing plastic, glass, metal, and other materials to reduce the need to refine new raw materials (Kirchherr et al., 2023; Yang et al., 2023; Munaro & Tavares, 2023).

The rapidly increasing amount of waste is a global problem, of which organic waste accounts for a significant proportion (Kalita et al., 2020; Castro-Aguirre et al.). Composting is an efficient and effective way of converting organic waste into fertiliser, returning compost to agricultural land while reducing pollution (Borrello et al., 2017; Talwar et al., 2023). Stimulation of biodegradation is organic waste composting, such as food residues and vegetable waste, which can be useful as a fertiliser for natural plants or soil. This reduces the amount of organic waste in landfills and promotes the natural material cycle (Ajmal et al., 2020; Soto-Paz et al., 2021). Education and information on waste management techniques can help people understand the importance of the waste problem and raise their awareness so that they can act in a more environmentally friendly way (Soma et al., 2020; Abbasi et al., 2020; Szakos et al., 2021).

5. Recycling practices for different types of waste

Every year, the world generates an enormous amount of waste, which becomes one of the biggest environmental challenges. According to World Bank statistics, municipal waste could reach around 2.2 billion tonnes annually by 2025. Municipal, bio, and plastic waste are the three main categories of waste that are of great concern for their environmental impact (Pluskal et al., 2021). In this article, we will examine these three types of waste and the most important methods and options for recycling. Each person generates more than 1 ton of waste in a year alone. This huge part of the waste stream includes municipal waste, bio-waste, and plastic garbage. Such an intense pace of waste production poses a significant environmental challenge and requires effective recycling solutions (Kumari et al., 2019; Hasan et al., 2021). Recycling is becoming an increasingly important factor in the fight against the waste problem. The recycling of municipal, bio and plastic waste not only helps reduce landfill waste but also makes it possible to use waste as a resource for producing new products, thus contributing to developing a sustainable economy (Ajmal et al., 2020).

This article will examine the processes, principles, and options for recycling municipal, bio, and plastic waste. Understanding the importance of recycling this waste and effective recycling methods is essential to the environmental and sustainability challenge. In Table 3, we present the methods of recycling the selected types of waste.

Table 3. Recycling methods specific to types of waste

Type of waste	Recycling method	Description	References
Municipal waste	Burning and obtaining energy	Part of the municipal waste can be used as a source of oxygen for energy production. This is a normal process, especially when recycling particular waste is impossible or inefficient.	Mahari et al., 2021; Kumari et al., 2019; Hasan et al., 2021
	Composting	It can be recycled into compost to reduce the amount of organic waste that does not need to be incinerated or stored in landfills.	Ajmal et al., 2020; Oviedo-Soto-Paz et al., 2021
	Processing into secondary raw materials	Municipal waste, glass, plastic, metal, and paper can be recycled into secondary raw materials and used to produce new products.	Spooren et al., 2020; Pleissner & Peinemann, 2020; Vincevica-Gaile et al., 2021
Bio-waste	Composting	Biofluents such as food residues, green garden and garden waste, liquid and solid food waste in industrial production, sludge, animal manure, and slurry can be processed through composting. They are considered biodegradable and can be used as a fertiliser for growing plants.	Soto-Paz et al., 2021; Oviedo-Chia et al., 2020; Oviedo-Ocaña et al., 2023
	Anaerobic decomposition	This process breaks down biofacts containing organic matter without the presence of air. This can be beneficial for biofuel production or energy production.	Chavez-Rico et al., 2022; Hasan et al., 2023
Plastic	Mechanical processing	Plastic can be crushed into small pieces and used to manufacture various products. This process is often used for recycling plastic bottles or boxes.	Feil & Pretz, 2020; Vollmer et al., 2020; Thiounn & Smith, 2020; Schyns & Shaver, 2021

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2024 Volume 11 Number 3 (March)
http://doi.org/10.9770/jesi.2024.11.3(29)

	Chemical processing	Some plastics can be chemically processed into secondary raw materials or for energy production. Applicable when mechanical processing is impossible or inefficient.	Vollmer et al., 2020; Thiounn & Smith, 2020; Schyns & Shaver, 2021
	Restorative technologies	New technologies make it possible to restore plastic molecules to their original state, allowing plastic reuse without losing quality.	Kichu & Devi, 2021; Martin et al., 2022

Properly managing biodegradable waste makes it possible to avoid adverse environmental effects and has some benefits (Malav et al., 2020; Mahari et al., 2021). From this waste, you can get the electricity and biogas necessary for producing thermal energy and the excellent fertiliser of the earth – compost. These ways and principles may vary by region, technology, and laws. But, the general idea is to minimise the amount of waste, recycle it into new products, or use it as a resource for other areas of production or energy production. The most common practice in developing countries is the recovery of energy from municipal (solid) waste using thermal technologies such as gasification, pyrolysis, and incineration to convert the waste into energy (Kumari et al., 2019; Hasan et al., 2021) and biological technologies for composting (Ajmal et al., 2020; Soto-Paz et al., 2021). In Table 4, the authors presented the advantages and disadvantages of municipal waste, biowaste, and plastic recycling.

Table 4. Advantages and disadvantages of waste recycling

Type of waste	Waste recycling advantages	Description of advantages	Waste recycling disadvantages	Description of disadvantages
Municipal waste	Reduced landfill load	Recycling reduces the amount of waste that would finally be dumped in landfills, thus reducing the load on these sites over time and preserving natural resources.	Processing costs	Recycling can be expensive, especially if particular technologies or equipment are required, leading to additional costs.
	Energy production	Some municipal waste, such as biomass and waste fuel, can be used for energy production. Recycling processes, such as producing fuels from waste, can help reduce dependence on fossil fuels and greenhouse gas emissions.	Complexity	Sorting and recycling municipal waste can be difficult and require additional efforts and resources from the country's residents and authorities.
	Preservation of effluents/ Secondary raw materials	Recycling municipal waste makes it possible to obtain secondary raw materials that can be used to produce new products, thereby reducing the need to extract new natural resources.	Technological limitations	Some wastes may be difficult to recycle due to their composition or technological challenges, which can complicate the effectiveness of recycling.
	Environment protection	By reducing waste and recycling efficiently, emissions of pollutants and environmental impacts, such as pollution of precipitation waters and soil, are reduced.		
Bio-waste	Compost production	Bio-waste processing can benefit compost production, which can be used as a natural fertiliser for plants, promoting sustainable agriculture.	Costs	Bio-waste recycling technologies may require significant investments and actions to develop efficient recycling facilities.
	Biofuel production	The process of anaerobic decomposition can be used to produce biofuels, which can be helpful in energy production or as a heating source.	Hazardous emissions	Anaerobic degradation can lead to emissions of dangerous gases, such as methane, a potent greenhouse gas.
Plastic	Secondary raw materials	Recycling plastic waste allows you to get secondary raw materials that can be used to produce new plastic products.	Complexity	Plastic recycling can be complex and requires special equipment and technologies to obtain quality secondary products.
	Environment protection	Reducing plastic waste and recycling reduces plastic pollution in seas, rivers, and forests.	Limited recycling options	Some types of plastics may be difficult to recycle due to their composition or technological challenges, limiting the ability to recycle them efficiently.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2024 Volume 11 Number 3 (March)
http://doi.org/10.9770/jesi.2024.11.3(29)

The advantages outlined in Table 4 show that recycling is a necessary measure from an environmental point of view regarding waste reduction and that it is, therefore, essential to find a way to ensure that the shortcomings listed can be addressed.

6. Research design and results

The authors applied the Vector Error Correction Model to analyse the relationship between two variables. The Vector Error Correction Model is a cointegrated VAR model—related to the Vector Error Correction Model (VECM). Panel VECM connection was determined between the indicator of resource productivity and domestic material consumption (measured in Euro per kilogram, chain-linked volumes) and the indicator of recycled waste biowaste:

1. Resource productivity and domestic material consumption Euro per kilogram, chain-linked volumes (RPDMCECHV)
2. REC_BIOW – Recycling of biowaste.

The Panel Vector Error Correction (VECM) model is a statistical method used to analyse the relationship between several variable time series, considering both short- and long-term equilibrium conditions. In this context, indicators of the productivity of resources and recycled waste, particularly bio-waste, are essential. The yearly data for the research was collected from the Eurostat (2024) database for 27 European countries on the indicators mentioned above.

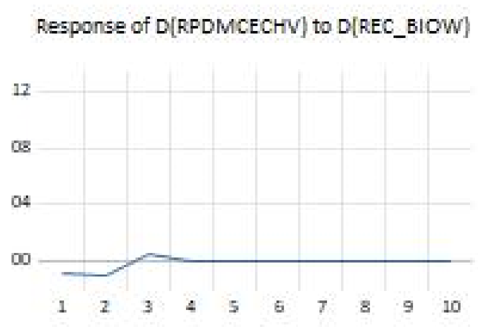

Figure 1. Relationship between indicators indicated after applying the VECM method

As we see from Figure 1, in the third period, the response was positive.

Table 5 below shows the relationship between the above-mentioned indicators in different periods.

Table 5. Response of D(RPDMCECHV)

Period	D(REC_BIOW)
1	-0.0088
2	-0.0101
3	0.0048
4	0.0005
5	-0.0002
6	0.0004
7	0.0004
8	0.0003
9	0.0004
10	0.0004

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2024 Volume 11 Number 3 (March)
http://doi.org/10.9770/jesi.2024.11.3(29)

The Resource Productivity Index, measured in euros per kilogram of material consumption in the household chain volume, shows how efficiently resources are used in the economy. A higher value means higher economic output per unit of material consumed, indicating higher resource productivity.

On the other hand, recycled waste, especially bio-waste, accounts for a high proportion of biodegradable waste that is recycled or reused rather than landfilled or incinerated. This indicator is essential when assessing environmental sustainability and waste management practices.

Conclusions

An analysis of the scientific literature has shown that there is a lack of research on the transition towards a sustainable circular economy, which aims to preserve the value of raw materials and manufactured products in the market for as long as possible by recycling waste and natural resources and by ensuring a more efficient economic system that contributes to the goals of the United Nations Sustainable Development Agenda. The paper's authors described recycling variables with the highest correlation to operational productivity that promotes interaction with the circular economy to fill an identified research gap. The novelty of this paper lies in the authors showing how a selection of significant recycling variables influences the transition to a circular economy, indicating the advantages and disadvantages of these processes.

The methodology developed is suitable for studying a wider range of overfilling variables for the comparative analysis of the transition to the circular economy.

Novelty of research. A sustainable transition to a circular economy has many interlinkages with achieving economic efficiency and managing different types of waste. The interactions are significant as they allow the possibility of promoting the diversion of various kinds of waste to protect the environment and preserve natural resources. The authors of this paper have carried out a study and identified the recycling variables that have the most significant impact on the transition to a circular economy.

Recycling significantly impacts the transition to a circular economy. The authors proposed a novel model analysing the time series relationship of several variables. Considering short-run and long-run equilibrium conditions, the importance of resource and productivity indicators for recycled waste, especially bio-waste, was determined.

The researchers looked at the variables necessary for recycling, excluding less important ones. They applied a Vector Error Correction Model to analyse the relationship between the two variables. They found a panel VECM relationship between resource productivity, the internal material consumption indicator, and the recycled biodegradable waste indicator.

This methodology could be helpful for those interested in the impact of recycling indicators on the transition to a circular economy. Recycled waste can reduce the need for resource extraction, as reusable materials are collected and reused in the production process. Primary resource extraction needs decrease due to lower demand for raw materials, resulting in lower waste generation and reduced environmental impact, contributing to nature conservation. Decreasing the use of materials will positively impact the environment. In the meantime, this requires assessments relating to the use of resources, the contribution of resources to economic development, and an assessment of the macroeconomic benefits associated with increasing resource efficiency. Policy evaluation should also be strengthened to identify good practices and pursue better CE implementation policies.

The study has some limitations. The authors analysed only bio-waste since variables responded to the changes in resource productivity indicators. It is possible to prepare forecasts considering other waste types in the future.

ISSN 2345-0282 (online) http://jssidoi.org/jesi/
2024 Volume 11 Number 3 (March)
http://doi.org/10.9770/jesi.2024.11.3(29)

References

Abbasi, A., Araban, M., Heidari, Z., Alidosti, M., & Zamani-Alavijeh, F. (2020). Comparing the impact of educational messages based on an extended parallel process model on solid waste separation behaviors in female students: A four-group randomised trial. *Waste Management*, 117, 1-8. https://doi.org/10.1016/j.wasman.2020.07.041

Adami, L., & Schiavon, M. (2021). From circular economy to circular ecology: a review on the solution of environmental problems through circular waste management approaches. *Sustainability*, 13(2), 925. https://doi.org/10.3390/su13020925

Aithal, S., & Aithal, P. S. (2023). Importance of Circular Economy for Resource Optimization in Various Industry Sectors-A Review-based Opportunity Analysis. *International Journal of Applied Engineering and Management Letters (IJAEML)*, 7(2), 191-215. https://doi.org/10.47992/IJAEML.2581.7000.0182

Ajmal, M., Aiping, S., Uddin, S., Awais, M., Faheem, M., Ye, L., ... & Shi, Y. (2020). A review on mathematical modeling of in-vessel composting process and energy balance. *Biomass Conversion and Biorefinery*, 1-13. https://doi.org/10.1007/s13399-020-00883-y

Balwada, J., Samaiya, S., & Mishra, R. P. (2021). Packaging plastic waste management for a circular economy and identifying a better waste collection system using analytical hierarchy process (AHP). *Procedia CIRP*, 98, 270-275. https://doi.org/10.1016/j.procir.2021.01.102

Belmonte-Ureña, L. J., Plaza-Úbeda, J. A., Vazquez-Brust, D., & Yakovleva, N. (2021). Circular economy, degrowth and green growth as pathways for research on sustainable development goals: A global analysis and future agenda. *Ecological Economics*, 185, 107050. https://doi.org/10.1016/j.ecolecon.2021.107050

Bisinella, V., Hulgaard, T., Riber, C., Damgaard, A., & Christensen, T. H. (2021). Environmental assessment of carbon capture and storage (CCS) as a post-treatment technology in waste incineration. *Waste Management*, 128, 99-113. https://doi.org/10.1016/j.wasman.2021.04.046

Borrello, M., Caracciolo, F., Lombardi, A., Pascucci, S., & Cembalo, L. (2017). Consumers' perspective on circular economy strategy for reducing food waste. *Sustainability*, 9(1), 141. https://doi.org/10.3390/su9010141

Burinskienė, A., Lingaitienė, O., & Jakubavičius, A. (2022). Core elements affecting the circularity of materials. *Sustainability*, 14(14), 8367. https://doi.org/10.3390/su14148367

Castro-Aguirre, E., Auras, R., Selke, S., Rubino, M., & Marsh, T. (2017). Insights on the aerobic biodegradation of polymers by analysis of evolved carbon dioxide in simulated composting conditions. *Polymer Degradation and Stability*, 137, 251-271. https://doi.org/10.1016/j.polymdegradstab.2017.01.017

Chavez-Rico, V. S., Bodelier, P. L., van Eekert, M., Sechi, V., Veeken, A., & Buisman, C. (2022). Producing organic amendments: Physicochemical changes in biowaste used in anaerobic digestion, composting, and fermentation. *Waste Management*, 149, 177-185. https://doi.org/10.1016/j.wasman.2022.06.005

Chia, W. Y., Chew, K. W., Le, C. F., Lam, S. S., Chee, C. S. C., Ooi, M. S. L., & Show, P. L. (2020). Sustainable utilisation of biowaste compost for renewable energy and soil amendments. *Environmental Pollution*, 267, 115662. https://doi.org/10.1016/j.envpol.2020.115662

Coelho, P. M., Corona, B., ten Klooster, R., & Worrell, E. (2020). Sustainability of reusable packaging-Current situation and trends. *Resources, Conservation & Recycling*: *X*, 6, 100037. https://doi.org/10.1016/j.rcrx.2020.100037

Cottafava, D., Costamagna, M., Baricco, M., Corazza, L., Miceli, D., & Riccardo, L. E. (2021). Assessment of the environmental break-even point for deposit return systems through an LCA analysis of single-use and reusable cups. *Sustainable Production and Consumption*, 27, 228-241. https://doi.org/10.1016/j.spc.2020.11.002

Cui, T., & Zhang, Y. (2022). Research on the impact of circular economy on total factor carbon productivity in China. *Environmental Science and Pollution Research*, 29(52), 78780-78794. https://doi.org/10.1007/s11356-022-21314-7

da Silva, D. J., & Wiebeck, H. (2020). Current options for characterising, sorting, and recycling polymeric waste. *Progress in Rubber, Plastics and Recycling Technology*, 36(4), 284-303. https://doi.org/10.1177/1477760620918603

Den Hollander, M. C., Bakker, C. A., & Hultink, E. J. (2017). Product design in a circular economy: Development of a typology of key concepts and terms. *Journal of Industrial Ecology*, 21(3), 517-525. https://doi.org/10.1111/jiec.12610

Di Foggia, G., & Beccarello, M. (2021). Designing waste management systems to meet circular economy goals: The Italian case. *Sustainable Production and Consumption*, 26, 1074-1083. https://doi.org/10.1016/j.spc.2021.01.002

Ding, L. L., Lei, L., Wang, L., & Zhang, L. F. (2020). Assessing industrial circular economy performance and its dynamic evolution: An extended Malmquist index based on cooperative game network DEA. *Science of the Total Environment*, 731, 139001. https://doi.org/10.1016/j.scitotenv.2020.139001

Du Rietz, S. (2023). Making up circular consumers: young adults' personal accounting and counter earmarking within a circular deposit-refund scheme. *Accounting Forum*, 47(4), 525-552. https://doi.org/10.1080/01559982.2022.2149045

Eurostat (2024). Resource productivity statistics. Available at the Internet https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Resource_productivity_statistics

Feil, A., & Pretz, T. (2020). Mechanical recycling of packaging waste. In Plastic waste and recycling (pp. 283-319). Academic Press. https://doi.org/10.1016/B978-0-12-817880-5.00011-6

Figge, F., & Thorpe, A. S. (2023). Circular economy, operational eco-efficiency, and sufficiency. An integrated view. *Ecological Economics*, 204, 107692. https://doi.org/10.1016/j.ecolecon.2022.107692

Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy-A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757-768. https://doi.org/10.1016/j.jclepro.2016.12.048

Gusmerotti, N. M., Carlesi, S., Iannuzzi, T., & Testa, F. (2023). The role of tourism in boosting circular transition: a measurement system based on a participatory approach. *Journal of Sustainable Tourism,* 1-25. https://doi.org/10.1080/09669582.2023.2190056

Hasan, M. M., Rasul, M. G., Khan, M. M. K., Ashwath, N., & Jahirul, M. I. (2021). Energy recovery from municipal solid waste using pyrolysis technology: A review on current status and developments. *Renewable and Sustainable Energy Reviews*, 145, 111073. https://doi.org/10.1016/j.rser.2021.111073

Hasan, M. R., Anzar, N., Sharma, P., Malode, S. J., Shetti, N. P., Narang, J., & Kakarla, R. R. (2023). Converting biowaste into sustainable bioenergy through various processes. *Bioresource Technology Reports*, 101542. https://doi.org/10.1016/j.biteb.2023.101542

Yang, M., Chen, L., Wang, J., Msigwa, G., Osman, A. I., Fawzy, S., ... & Yap, P. S. (2023). Circular economy strategies for combating climate change and other environmental issues. *Environmental Chemistry Letters*, 21(1), 55-80. https://doi.org/10.1007/s10311-022-01499-6

Istrate, I. R., Galvez-Martos, J. L., Vázquez, D., Guillén-Gosálbez, G., & Dufour, J. (2023). Prospective analysis of the optimal capacity, economics and carbon footprint of energy recovery from municipal solid waste incineration. *Resources, Conservation and Recycling*, 193, 106943. https://doi.org/10.1016/j.resconrec.2023.106943

Yusuf, R., & Fajri, I. (2022). Differences in behavior, engagement and environmental knowledge on waste management for science and social students through the campus program. *Heliyon*, 8(2). https://doi.org/10.1016/j.heliyon.2022.e08912

Kalita, N. K., Bhasney, S. M., Kalamdhad, A., & Katiyar, V. (2020). Biodegradable kinetics and behavior of bio-based polyblends under simulated aerobic composting conditions. *Journal of Environmental Management*, 261, 110211. https://doi.org/10.1016/j.jenvman.2020.110211

Katakojwala, R., Advaitha, K., Patil, J. K., & Mohan, S. V. (2023). Circular Economy Induced Resilience in Socio-Ecological Systems: an Ecolonomic Perspective. *Materials Circular Economy*, 5(1), 4. https://doi.org/10.1007/s42824-023-00074-w

Khandelwal, H., Dhar, H., Thalla, A. K., & Kumar, S. (2019). Application of life cycle assessment in municipal solid waste management: A worldwide critical review. *Journal of Cleaner Production*, 209, 630-654. https://doi.org/10.1016/j.jclepro.2018.10.233

Kichu, A., & Devi, N. (2021). Utilisation of Plastic Wastes and Its Technologies: An Overview. Handbook of Solid Waste Management: *Sustainability through Circular Economy*, 1-22. https://doi.org/10.1007/978-981-15-7525-9_50-1

Kirchherr, J., Yang, N. H. N., Schulze-Spüntrup, F., Heerink, M. J., & Hartley, K. (2023). Conceptualising the Circular Economy (Revisited): An Analysis of 221 Definitions. Resources. *Conservation and Recycling*, 194, 107001. https://doi.org/10.1016/j.resconrec.2023.107001

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

Kumari, K., Kumar, S., Rajagopal, V., Khare, A., & Kumar, R. (2019). Emission from open burning of municipal solid waste in India. *Environmental Technology,* 40(17), 2201-2214. https://doi.org/10.1080/09593330.2017.1351489

Lange, J. P. (2021). Managing plastic waste─ sorting, recycling, disposal, and product redesign. *ACS Sustainable Chemistry & Engineering*, 9(47), 15722-15738. https://doi.org/10.1021/acssuschemeng.1c05013

Lim, J., Ahn, Y., Cho, H., & Kim, J. (2022). Optimal strategy to sort plastic waste considering economic feasibility to increase recycling efficiency. *Process Safety and Environmental Protection*, 165, 420-430. https://doi.org/10.1016/j.psep.2022.07.022

Linderhof, V., Oosterhuis, F. H., Van Beukering, P. J., & Bartelings, H. (2019). Effectiveness of deposit-refund systems for household waste in the Netherlands: Applying a partial equilibrium model. *Journal of Environmental Management*, 232, 842-850. https://doi.org/10.1016/j.jenvman.2018.11.102

Lingaitienė, O., & Burinskienė, A. (2021). Core elements towards circularity: Evidence from the European countries. *Sustainability*, 13(16), 8742. https://doi.org/10.3390/su13168742

Lingaitienė, O., Burinskienė, A., & Davidavičienė, V. (2022). Case study of municipal waste and its reliance on reverse logistics in European countries. *Sustainability*, 14(3), 1809. https://doi.org/10.3390/su14031809

Lu, H., Zhao, G., & Liu, S. (2024). Integrating circular economy and Industry 4.0 for sustainable supply chain management: a dynamic capability view. *Production Planning & Control*, 35(2), 170-186. https://doi.org/10.1080/09537287.2022.2063198

Magriotis, Z. M., Saczk, A. A., Salgado, H. M. R., & Rosa, I. A. (2021). Chemical waste management in educational institutions. *Journal of Environmental Science and Sustainable Development*, 4(1), 160-176. https://doi.org/10.7454/jessd.v4i1.1064

Mahari, W. A. W., Azwar, E., Foong, S. Y., Ahmed, A., Peng, W., Tabatabaei, M., ... & Lam, S. S. (2021). Valorisation of municipal wastes using co-pyrolysis for green energy production, energy security, and environmental sustainability: A review. *Chemical Engineering Journal*, 421, 129749. https://doi.org/10.1016/j.cej.2021.129749

Martin, N., Mulligan, S., Fuzesi, P., & Hatton, P. V. (2022). Quantification of single use plastics waste generated in clinical dental practice and hospital settings. *Journal of Dentistry*, 118, 103948. https://doi.org/10.1016/j.jdent.2022.103948

Mavi, N. K., & Mavi, R. K. (2019). Energy and environmental efficiency of OECD countries in the context of the circular economy: Common weight analysis for malmquist productivity index. *Journal of Environmental Management*, 247, 651-661. https://doi.org/10.1016/j.jenvman.2019.06.069

Mintz, K. K., Henn, L., Park, J., & Kurman, J. (2019). What predicts household waste management behaviors? Culture and type of behavior as moderators. *Resources, Conservation and Recycling*, 145, 11-18. https://doi.org/10.1016/j.resconrec.2019.01.045

Moraga, G., Huysveld, S., De Meester, S., & Dewulf, J. (2022). Resource efficiency indicators to assess circular economy strategies: a case study on four materials in laptops. *Resources, Conservation and Recycling*, 178, 106099. https://doi.org/10.1016/j.resconrec.2021.106099

Mostaghimi, K., & Behnamian, J. (2023). Waste minimisation towards waste management and cleaner production strategies: a literature review. Environment. *Development and Sustainability*, 25(11), 12119-12166. https://doi.org/10.1007/s10668-022-02599-7

Mukherjee, A. G., Wanjari, U. R., Chakraborty, R., Renu, K., Vellingiri, B., George, A., ... & Gopalakrishnan, A. V. (2021). A review on modern and smart technologies for efficient waste disposal and management. *Journal of Environmental Management*, 297, 113347. https://doi.org/10.1016/j.jenvman.2021.113347

Munaro, M. R., & Tavares, S. F. (2023). A review on barriers, drivers, and stakeholders towards the circular economy: The construction sector perspective. *Cleaner and Responsible Consumption*, 100107. https://doi.org/10.1016/j.clrc.2023.100107

Nobre, G. C., & Tavares, E. (2021). The quest for a circular economy final definition: A scientific perspective. *Journal of Cleaner Production*, 314, 127973. https://doi.org/10.1016/j.jclepro.2021.127973

Oviedo-Ocaña, E. R., Abendroth, C., Domínguez, I. C., Sánchez, A., & Dornack, C. (2023). Life cycle assessment of biowaste and green waste composting systems: A review of applications and implementation challenges. *Waste Management*, 171, 350-364. https://doi.org/10.1016/j.wasman.2023.09.004

Parajuly, K., Fitzpatrick, C., Muldoon, O., & Kuehr, R. (2020). Behavioral change for the circular economy: A review with focus on electronic waste management in the EU. *Resources, Conservation & Recycling*: X, 6, 100035. https://doi.org/10.1016/j.rcrx.2020.100035

Patwa, N., Sivarajah, U., Seetharaman, A., Sarkar, S., Maiti, K., & Hingorani, K. (2021). Towards a circular economy: An emerging economies context. *Journal of Business Research*, 122, 725-735. https://doi.org/10.1016/j.jbusres.2020.05.015

Petrariu, R., Sacala, M.-D., Pistalu, M, Dinu, M., Deaconu, M.E., Constantin, M. (2022). A Comprehensive Food Consumption and Waste Analysis Based on eCommerce Behaviour in the Case of the AFER Community, *Transformations in Business & Economics*, Vol. 21, No 3(57), pp.168-187.

Pleissner, D., & Peinemann, J. C. (2020). The challenges of using organic municipal solid waste as source of secondary raw materials. *Waste and Biomass Valorization*, 11, 435-446. https://doi.org/10.1007/s12649-018-0497-1

Pluskal, J., Šomplák, R., Nevrlý, V., Smejkalová, V., & Pavlas, M. (2021). Strategic decisions leading to sustainable waste management: Separation, sorting and recycling possibilities. *Journal of Cleaner Production*, 278, 123359. https://doi.org/10.1016/j.jclepro.2020.123359

Prieto-Sandoval, V., Jaca, C., Santos, J., Baumgartner, R. J., & Ormazabal, M. (2019). Key strategies, resources, and capabilities for implementing circular economy in industrial small and medium enterprises. *Corporate Social Responsibility and Environmental Management*, 26(6), 1473-1484. https://doi.org/10.1002/csr.1761

Ruiz, L. A. L., Ramón, X. R., & Domingo, S. G. (2020). The circular economy in the construction and demolition waste sector-A review and an integrative model approach. *Journal of Cleaner Production*, 248, 119238. https://doi.org/10.1016/j.jclepro.2019.119238

Sakai, S. I., Yano, J., Hirai, Y., Asari, M., Yanagawa, R., Matsuda, T., ... & Moore, S. (2017). Waste prevention for sustainable resource and waste management. *Journal of Material Cycles and Waste Management*, 19, 1295-1313. https://doi.org/10.1007/s10163-017-0586-4

Salmenperä, H., Pitkänen, K., Kautto, P., & Saikku, L. (2021). Critical factors for enhancing the circular economy in waste management. *Journal of Cleaner Production*, 280, 124339. https://doi.org/10.1016/j.jclepro.2020.124339

Schaltegger, S., Lüdeke-Freund, F., & Hansen, E. G. (2016). Business models for sustainability: A co-evolutionary analysis of sustainable entrepreneurship, innovation, and transformation. *Organization & Environment*, 29(3), 264-289. https://doi.org/10.1177/1086026616633272

Schyns, Z. O., & Shaver, M. P. (2021). Mechanical recycling of packaging plastics: A review. *Macromolecular Rapid Communications*, 42(3), 2000415. https://doi.org/10.1002/marc.202000415

Sehnem, S., de Queiroz, A. A. F. S., Pereira, S. C. F., dos Santos Correia, G., & Kuzma, E. (2022). Circular economy and innovation: A look from the perspective of organisational capabilities. *Business Strategy and the Environment*, 31(1), 236-250. https://doi.org/10.1002/bse.2884

Serranti, S., & Bonifazi, G. (2019). Techniques for separation of plastic wastes. In use of recycled plastics in eco-efficient concrete (pp. 9-37). Woodhead Publishing. https://doi.org/10.1016/B978-0-08-102676-2.00002-5

Sherwood, J. (2020). The significance of biomass in a circular economy. *Bioresource Technology*, 300, 122755. https://doi.org/10.1016/j.biortech.2020.122755

Siddiqua, A., Hahladakis, J. N., & Al-Attiya, W. A. K. (2022). An overview of the environmental pollution and health effects associated with waste landfilling and open dumping. *Environmental Science and Pollution Research*, 29(39), 58514-58536. https://doi.org/10.1007/s11356-022-21578-z

Skene, K. R. (2018). Circles, spirals, pyramids and cubes: why the circular economy cannot work. *Sustainability Science*, 13(2), 479-492. https://doi.org/10.1007/s11625-017-0443-3

Soma, T., Li, B., & Maclaren, V. (2020). Food waste reduction: A test of three consumer awareness interventions. *Sustainability*, 12(3), 907. https://doi.org/10.3390/su12030907

Soto-Paz, J., Gea, T., Alfonso-Morales, W., Caicedo-Bravo, E., Oviedo-Ocaña, E. R., Manyoma-Velásquez, P. C., & Torres-Lozada, P. (2021). Co-composting of biowaste: simultaneous optimisation of the process and final product quality using simulation and optimisation tools. *Waste and Biomass Valorization*, 12, 4489-4502. https://doi.org/10.1007/s12649-020-01321-w

Spooren, J., Binnemans, K., Björkmalm, J., Breemersch, K., Dams, Y., Folens, K., ... & Kinnunen, P. (2020). Near-zero-waste processing of low-grade, complex primary ores and secondary raw materials in Europe: technology development trends. Resources, Conservation and Recycling, 160, 104919. https://doi.org/10.1016/j.resconrec.2020.104919

Suchek, N., Fernandes, C. I., Kraus, S., Filser, M., & Sjögrén, H. (2021). Innovation and the circular economy: A systematic literature review. *Business Strategy and the Environment*, 30(8), 3686-3702. https://doi.org/10.1002/bse.2834

Sverko Grdic, Z., Krstinic Nizic, M., & Rudan, E. (2020). Circular economy concept in the context of economic development in EU countries. *Sustainability*, 12(7), 3060. https://doi.org/10.3390/su12073060

Szakos, D., Szabó-Bódi, B., & Kasza, G. (2021). Consumer awareness campaign to reduce household food waste based on structural equation behavior modeling in Hungary. *Environmental Science and Pollution Research*, 28, 24580-24589. https://doi.org/10.1007/s11356-020-09047-x

Talwar, S., Kaur, P., Ahmed, U., Bilgihan, A., & Dhir, A. (2023). The dark side of convenience: How to reduce food waste induced by food delivery apps. *British Food Journal*, 125(1), 205-225. https://doi.org/10.1108/BFJ-02-2021-0204

Thiounn, T., & Smith, R. C. (2020). Advances and approaches for chemical recycling of plastic waste. *Journal of Polymer Science*, 58(10), 1347-1364. https://doi.org/10.1002/pol.20190261

Vincevica-Gaile, Z., Teppand, T., Kriipsalu, M., Krievans, M., Jani, Y., Klavins, M., ... & Burlakovs, J. (2021). Towards sustainable soil stabilisation in peatlands: Secondary raw materials as an alternative. *Sustainability*, 13(12), 6726. https://doi.org/10.3390/su13126726

Vollmer, I., Jenks, M. J., Roelands, M. C., White, R. J., van Harmelen, T., de Wild, P., ... & Weckhuysen, B. M. (2020). Beyond mechanical recycling: Giving new life to plastic waste. *Angewandte Chemie International Edition*, 59(36), 15402-15423. https://doi.org/10.1002/anie.201915651

Voukkali, I., Papamichael, I., Loizia, P., Lekkas, D. F., Rodríguez-Espinosa, T., Navarro-Pedreño, J., & Zorpas, A. A. (2023). Waste metrics in the framework of circular economy. *Waste Management & Research*, 41(12), 1741-1753. https://doi.org/10.1177/0734242X231190794

Xijie, J., Rim, G. N., & An, C. J. (2023). Some methodological issues in assessing the efforts for the circular economy by region or country. *SAGE Open*, 13(3), 21582440231184863. https://doi.org/10.1177/21582440231184863

Author Contributions: Conceptualisation: *O.L. and A. B.*; methodology: *A.B.*; data analysis: *V. G;* writing—original draft preparation: *O.L.*, writing; review and editing: *O.L. and A. B.*; visualisation: *V. G.* All authors have read and agreed to the published version of the manuscript.

Olga LINGAITIENĖ Assoc. Prof. at Business Management Faculty, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT-10223 Vilnius, Lithuania. Research interests: circular economy, green logistics, sharing economy, waste management, sustainability, supply chain management.
ORCID ID: https://orcid.org/0000-0002-7479-0127

Aurelija BURINSKIENĖ Prof. at Business Management Faculty, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT-10223 Vilnius, Lithuania. Research interests: circular economy, green logistics, sharing economy, waste management, sustainability, supply chain management.
ORCID ID: https://orcid.org/0000-0002-4369-8870

Valentas GRUŽAUSKAS Researcher at Business Management Faculty, Vilnius Gediminas Technical University, Sauletekio ave. 11, LT-10223 Vilnius, Lithuania. Research interests: circular economy, waste management, sustainability.
ORCID ID: https://orcid.org/0000-0002-6997-9275