CIRCULAR ECONOMY AFTER COVID-19 PANDEMIC

Senior Scientific Researcher, Ph.D. Corina GRIBINCEA
National Institute for Economic Research, Academy of Economic Studies of Moldova
E-mail: gribincea.corina@ase.md
ORCID ID 0000-0003-2571-5849

Abstract. *Managerial practice focuses largely on performance management. But because the Covid-19 pandemic has revealed the painful fragility of many of our systems, leaders are focusing on resilience; and with the loss of biodiversity, climate action and sustainable resource management should be a priority in the recovery phase. Sustainable management of natural resources, including smarter use of materials, has many benefits: it reduces the rate of depletion of natural resources. It generates opportunities, including low material supply dependencies and economic diversification towards resilient business models with a circular economy and jobs. Lower input levels help reduce waste streams and emissions and reduce costs for producers and consumers. In addition, it stimulates innovation, the creation of new industries and stimulates economic competitiveness. Objective: This article will examine the measurement of post-pandemic resilient business in the Republic of Moldova through circular economy indicators. Building and managing resilience and circularity in the private sector today will ensure a swifter and more sustainable economic recovery for the coming years; Method: Among many other aspects, we have highlighted the number of citations, their intertemporal evolution, those authors and publications with the greatest impact, the most common keywords, etc. In order to assess measurement of post-pandemic resilient business in Moldova through circular economy indicators, was conducted an interview based on perception of experts within analysed firms from food industry; Results: Finally, our study, has allowed us to carry out a deep analysis and focus on resilience post-Covid-19 that emphasizes sustainable resource management and the circular economy's potential to diversify feedstocks, localize resource sharing, and redesign manufacturing systems, necessitating extensive innovation and stakeholder engagement for a zero-waste, resilient future. Originality: The study's unique approach centers on merging post-Covid-19 resilience thinking with an emphasis on sustainable resource management, specifically highlighting how the circular economy can diversify feedstocks, facilitate local resource sharing, and transform manufacturing systems to realize a waste-free, resilient future through comprehensive innovation and engagement of stakeholders.*

The article was developed within the framework of Subprogram 030101 „Strengthening the resilience, competitiveness, and sustainability of the economy of the Republic of Moldova in the context of the accession process to the European Union", institutional funding.

Keywords*: Circular economy, Covid-19 pandemic, resilient business, performance management.*
JEL Classification*: M19, L25, Q01.*

1. Introduction

With the onset of the Covid 19 pandemic, humanity began to rethink how to address not only the recovery of the current situation, including lifestyle; The Covid crisis 19 is related not only to the health crisis, but also to the vulnerabilities related to the economic and social activity of mankind.

Sustainable management of natural resources, including smarter use of materials, has many benefits: it reduces the rate of depletion of natural resources. It generates opportunities, including reduced material supply dependencies and economic diversification to circular economy models. Lower input levels help reduce waste streams and emissions and reduce costs for producers and consumers. Smarter use of resources also limits the impact on the environment in different sectors of the economy. In addition, it stimulates innovation, the creation of new industries and stimulates economic competitiveness.

We believe that biodiversity loss, climate action and sustainable resource management should be a priority in the recovery phase. Decisions made by global leaders about resource use will shape our economies and societies for decades to come. Properly measuring the elements of resource efficiency can lead to cost savings and stimulate economic growth and is the cornerstone of crisis prevention and resilience.

This investigation has been organized into three main phases: 1) a literature review to derive the theoretical framework to operationalize circular economy under the environmental sustainability paradigm; 2) Systematization of the resilience and circularity indicators for business; and 3) measurement of circularity and firm's resilience in Moldova.

2. Literature review

Organizational resilience is a term used in business management to describe companies that face certain difficulties and must reinvent part or all their business strategy to survive (Briones, 2021). To continue to adapt, companies must combine digital tools and technologies, managerial practices, market insight and agility. This is more relevant in the context of the current pandemic, which has weakened many parts of the economy.

It is to be mentioned that the circular economy (CE) approach reduces externalities and resource depletion as small improvements in sustainable product design can result in resource efficiencies in production processes (Cooper, 1999; Camilleri, 2018). The concept focuses on the redesign of manufacturing and service systems. Closed loop systems reduce resource throughput in industrial production and consumption (Ghisellini et al., 2016; Camilleri, 2018). The recycling of resources has been a significant part of sustainability practices for many years (Barnes, 1982; Butler & Hooper, 1999; Geyer et al., 2016; Camilleri, 2018). The unwanted outputs of one industrial process may be used as raw materials in another industrial process. Redesigned manufacturing systems within the industry can improve resource utilisation as opposed to natural resource depletion and environmental degradation (Liu et al., 2009; Camilleri, 2018). As a result, the CE and its closed loop systems may lead to the sustainable development of the economy, environment, and society (Camilleri, 2017; Murray et al., 2017; Camilleri, 2018). The circulation of resources could regenerate the organizations' operational performance, whilst ensuring the protection of our environmental resources. The adoption of closed loop systems would increase the firms' operational efficiency of resource use in production (Bocken et al., 2014; Mont, 2002; Shrivastava, 1995; Zhang et al., 2017; Camilleri. 2018). According to Camilleri (2018), industrial operations can be improved through redesigned processes, the elimination of some of them, the modification of certain systems, and/or by introducing new technology. Prakash (2002) suggested that the businesses could adopt management systems that create the right conditions to reduce their negative impact on the natural environment (Camilleri, 2018). He posited that this could take place in the following ways: (a) repair—extend the life of a product by repairing its parts, (b) recondition—extend the life of a product by significantly overhauling it, (c) remanufacture—the new product is based on old ones; (d) reuse—design a product so that it can be used multiple times; (e) recycle—products can be reprocessed and converted into raw material to be used in another or the same product, and (f) reduce— even though the product uses less raw material or generates less disposable waste, it could still deliver benefits that are comparable to its former version. These preventative and restorative practices are related to the CE. The biological and/or technical nutrients that are used to produce goods and resources are either designed to re-enter the biosphere "safely," or to recirculate at high quality, without entering the biosphere (UNEP, 2006). Murray et al. (2017) suggested that sustainable production is optimized via biomimetic, wherein the structure and function of natural systems would inform responsible industrial processes (Camilleri, 2018). Therefore, closed loop systems emit lower emissions of pollutants and will result in high efficiencies for a sustainable industrial economy which is, by design or intention, restorative in nature. Similarly, in industrial symbiosis, eco-industrial parks (EIPs) use each other's waste as resources, where CE models would increase the longevity of products through better manufacturing and maintenance. Hence, the rate of replacement decreases, and the use of resources is considerably reduced. Firms of all sizes could engage in the CE's closed loop systems to extend the producers' liability, life-cycle analyses, material-use, and resource flows, for eco-efficiencies. Cooper (2012) pointed out that individual consumers would prefer using longer lasting products (Camilleri, 2018). Notwithstanding, such durable products would appear to provide added value for money to customers. The businesses as well as their consumers bear mutual responsibility on their consumption patterns

and on the collection of resources before their recycling or disposal. The consumers are expected to do their part in terms of sustainable consumption (EU, 2018). However, the targeting of consumers seems much more complicated than regulating the industrial production of goods and services (McDonald et al., 2009; Pollex, 2017; Camilleri, 2018).

Table 1. Summary of insights from the circular economy and resilience literature

Dimension	Circular economy	Resilience
Seminal works	Boulding (1966); McDonough and Braungart (2008); Pauli (2010)	Natural sciences: Holling (1973); Gunderson and Holling (2002) Management sciences: Meyer (1982)—environmental jolts; Weick and Roberts (1993)—collective mindfulness; Weick et al. (1999)—high reliability organizing
Definition	'Industrial systems that are restorative or regenerative by intention and design' (Ellen MacArthur Foundation, 2013, p. 7).	Natural sciences: 'The capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks' (Walker et al., 2004, para. 7) Management sciences: 'Organizations that are able to respond more quickly, recover faster or develop more unusual ways of doing business under duress than others' (Linnenluecke, 2017, p. 4)
Key principles	Material health (e.g., non-toxic products) Material recirculation Eliminate waste Renewable energy	Adaptability Transformability
Business practices	Narrowing loops Slowing loops Closing loops	Slack and buffer capacities diversification Redundancy

Source: Kennedy S, Linnenluecke M.K. (2022).

3. Methods

For the third part of the investigation (measurement of circularity and firm's resilience in Moldova) was conducted an interview based on perception of experts within analyzed firms from food industry. Most of the firms represents SMEs. The period of conducting interview covered first half of 2022. In Moldova restricting measures were removed starting from March 2022.

While analyzing resilience we took into consideration such indicators as: complexity, uncertainty, interdependence, systems thinking, and a multi-timescale perspective. Resisting, regenerating, reinventing are key catchphrases that have been considered in present paper.

4. Results

4.1. Building resilience and performance in the private sector

The pandemic has shown the strength of community - globally, locally, and across the private and third sectors. Harnessing this collaborative spirit will help us rebuild and secure a prosperous future for people and planet. Building this resilience in the private sector today will ensure a swifter and more sustainable economic recovery in the months and years to come. Resilience is especially important today because the business environment is becoming more dynamic and unpredictable. This is a result of several enduring forces stressing and stretching business systems - from accelerated technological evolution to a greater interconnectedness of the global economy to broader issues such as rising inequality, species depletion, and climate change (Reeves, Whitaker, 2020).

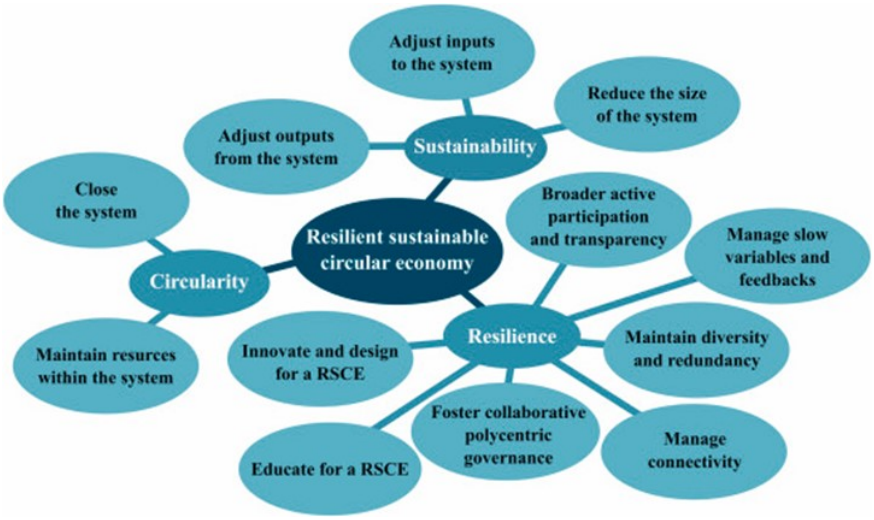

Figure 1. Operational principles for a resilient, sustainable and circular economy[3]

Source: Suárez-Eiroa, Fernández, Méndez (2021)

Circulytics represents the most comprehensive tool for companies interested in measuring their circular economy performance. Its development brings a series of improvements. If we consider circulytics there is a need to link it with (The Ellen MacArthur Foundation):

- *Circularity performance* - Measures a company's entire circularity, not just products and material flows;

[3] Note: Sustainability refers here to the analysis of the production-consumption system as a black box within the natural system, addressing inputs, outputs, and the size of the production-consumption system. Circularity makes reference to the maintenance of resources within the systems once they have been introduced addressing close-loop production-consumption patterns. Resilience represents the ability of the system to change, addressing elements that enhance and boost CE under the environmental sustainability paradigm.

• *Decision making* - Supports decision making and strategic development for circular economy adoption;
• *Strengths and blindspots* - Demonstrates strengths and highlights the areas for improvement;
• *Transparency* - Provides transparency and generates brand value to investors and customers about a company's circular economy adoption – if the company chooses to publish it;
• *Opportunities* - Delivers unprecedented clarity about circular economy performance, opening up new opportunities to generate brand value with key stakeholders.

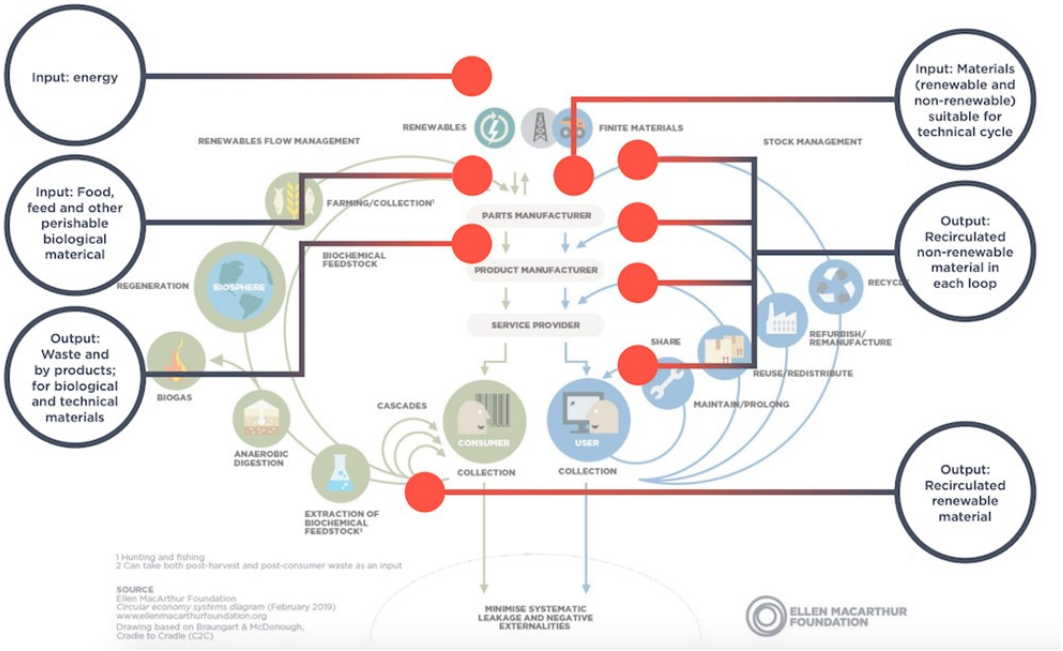

Figure 2. Circular economy systems

Source: Ho S. (2020)

We consider that many companies worldwide face misunderstanding how to evaluate their own circularity performance. In this regard a good base for them could serve provided systematization of the indicators for the firm's reference. Table 2 present main indicators for circularity performance.

Table 2. Firm's Circularity performance

Indicator	Formula
1. Resource productivity	$\text{Resource productivity} = \frac{\text{Total sales in \$}}{\text{Mass of virgin material inflow}}$
2. Percentage of non-virgin (renewed) material used	$\%\text{ of non virgin material inflow for production} = \frac{\text{Mass of renewed raw materials}}{\text{Mass of total raw materials}} \times 100$
3. Percentage of recyclability of product	Biodegradable, recyclable materials throughout the manufacturing process. The higher the percentage of recyclability of your product, the more likely other companies, including your own, will be able to use it as a source of raw material after recycling.
4. Percentage of circular water consumption	$\%\text{ of circular water consumption} = \frac{\text{Quantity of treated waste water consumption}}{\text{Quantity of total water consumption}} \times 100$
5. Percentage of circular water discharge	$\%\text{ of circular water discharge} = \frac{\text{Quantity of circular water discharge}}{\text{Quantity of total water consumption}} \times 100$
6. Percentage of renewable energy consumption	$\%\text{ of renewable energy consumption} = \frac{\text{Annual renewable energy consumption}}{\text{Total energy consumption}} \times 100$
7. Estimated environmental saving of rentals	Using "pay as you use" goods and services
8. Reparability of product	The greater reparability of the product is associated with longer usage duration since consumers can fix them. firms should focus on their design and produce as a decomposable way to enhance reparability.
9. Warranty period	Longevity of firms products
10. Progress towards goals	Analysis of the performance of a company's CE strategy

In regard to the *Circulytics,* Ellen MacArthur Foundation developed a tool Circulytics 2.0 that helps to inform action strategies. Such feature allows that users understand their performance level in relation to the industry. It provides practical insight for those moving away from the current linear economy of extracting logic, to produce, to waste (BiO3, 2021).

4.2. Circular economy and firm's resilience in Moldova

In the circular economy, material usage is reduced through narrowing, slowing and closing resource loops. However, from a resilience perspective, such strategies are seen as problematic as they may reduce the slack resources, diversity, and buffers required for adaptation and change (Biggs et al., 2012; Walker & Salt, 2006). Consequently, there appears to be a need to examine how circular economy business practices impact resilience.

Table 3. Firm's resilience in response to Circular economy business practice

Circular economy business practice	**Firm resilience**	
	Congruence	Contestation
Narrowing resource loops	Reduces firms dependences on virgin natural resources for value creation	Reduces functional and response diversity in search of optimal resource use; Firms may experience trade-offs between redundancy and the drive for efficiency
Slowing resource loops	Reduces firm's dependences on virgin natural resources for value creation; Stimulates improved functional and response diversity of product offerings and	Business models within sequential loops can be highly vulnerable to shocks such as changes in technology or fashion.

	customer segments	
Closing resource loops	Types of supply may become diverse; By increasing partners for exchange, firms may improve the availability of material substitutes; High interconnectivity may mean a faster and stronger response to shocks as resources can be quickly moved where they are needed.	Number of suppliers may become more limited; Firms may become exposed to a wider scope of shocks and disturbances.

Source: Kennedy S, Linnenluecke M.K. (2022).

At the firm level, resource efficiencies are generally expected to decrease dependence on virgin material resources for value creation (subject to rebound effects, discussed above) and thus improve firm resilience against supply shortages and price volatility (Ellen Mac-Arthur Foundation, 2013). Yet, maximizing resource efficiencies could increase brittleness and vulnerability by decreasing functional diversity (i.e., the range of current and future products and services that can be offered) and response diversity (i.e., the ability of a firm to switch to different products or services when a shock occurs). For instance, a firm may choose to optimize its production capabilities and sell only one product that requires the least materials. While such a strategy achieves resource savings, it might leave the firm susceptible to rapid changes in technology, sudden changes in fashion or product controversies. Relatedly, the drive for efficiency may lead a firm to remove redundancies that can protect against disruption (Skene, 2018; Kennedy S, Linnenluecke M.K., 2022).

Table 4. Results of the analysis of social-ecological resilience of the Moldovan firms

RESILIENCE PILLAR	Maintain diversity and redundancy	Manage connectivity	Manage slow variables and control feedback loops	Foster complex adaptive systems	Encourage learning	Broaden participation	Promote polycentric governance
Resource efficiency	+	✓					
Shared resources			✓			✓	✓
Regenerative resources	✓			✓			
Decentralization	✓	+				✓	✓
Lack of sociological foundation			+	+	+		
Labour mobility and skills transferability	✓						
Lifelong learning	✓				✓		
Flexibilisation of labour contracts	+						

Note: representation of the symbols : + risks; √ Opportunities

Source: Author's investigations

Transitioning to a circular economy means moving towards a system that builds natural capital and allows nature to thrive. With the circular economy, we can build a food system (e.g.) that ensures minimization of waste. It prevents food waste, redistribute surplus edible food to people who need it and inedible food by-products and human waste become inputs for new products (The Ellen MacArthur Foundation).

Table 5. Prioritization of CE metrics based on requirements and perception of experts within analyzed Moldovan firms

Material flow		Metric	Results
Input	Energy	Energy productivity (EC, 2015) Cumulative energy consumption (BMU, 2016) Share of renewable energy in gross final energy consumption (EC, 2015)	+
	Resources	Total Material Requirement (Mayer, 2019), Total Raw Material Productivity (BMU, 2016)	+
	Secondary materials	DERec (UBA, 2012), DIERec (UBA, 2012), National Circularity Metric (De Wit et al., 2019)	-
Use and stocks	Anthropogenic stocks	In-use stocks (Mayer et al., 2019)	+
	Material use	Consumption related material productivity (EC, 2014), Raw Material consumption per capita (Haas et al., 2015) Share of circular products in total number of products (Potting & Hanemaaijer, 2018) Circular Material Use Rate (EC, 2018)	+
R-Strategies	R1 Rethink	Number of new revenue models (Potting & Hanemaaijer, 2018)	-
	R2 Reduce	Value based resource efficiency indicator (Di Maio & Rem, 2017)	-
	R4 Repair	Household spending on product repair and maintenance (Magnier et al., 2017)	-
	R6 Remanufacture	Share of remanufacturing business in the	-

		manufacturing economy (EEA, 2016)	
	R8 Recycle	Substitutions quote (KRU, 2019) Recycling rate of all waste excluding major mineral waste (EC, 2018), Value based recycling index (Van Schaik and Reuter, 2016), Recycling process efficiency rate (Graedel et al., 2011), End of life recycling input rate (Graedel et al., 2011) Share of materials where safe recycling options exist(EEA, 2016), Material quality indicator (Steinmann et al., 2019)	-
Output	Waste generation	Generation of municipal waste per capita (EC, 2018), Quantities of waste sent to landfill (Magnier et al., 2017), Food waste (EC, 2018), Municipal waste collected selectively in relation to the total amount of municipal waste collected (Avidushchenko et al., 2019)	+

Sourse: author's investigations based on Kick M., Kadner S., Greiff K. et al. (2021)

5. Discussion

Analyzing the resource efficiency of Moldovan firms we found out that is still present the issue of application of *Reducing strategies* (minimizing consumption and waste) by the top management. Another issue is the fragile system that is vulnerable to shocks. A system with a sole focus on redundancy could result in wasteful supply chains, while a sole focus on resource efficiency could result in fragile supply chains. Importantly, any circular economy strategy striving for an effective system should strike the balance between the two (Dufourmont, Papú Carrone, Haigh, 2020).

In Moldova, businesses implementing circular practices own and manage private resources. So, waste flows are governed by regional waste management systems, cardboard municipal collections, or by collaborations between private entities. Other types of shared resources, such as knowledge, constitute the virtual commons and are governed globally through networks and in sharing economy settings. Shared resources in a circular economy can therefore broaden access and participation while supporting a transition towards a more just and equitable society.

Within Moldova's business environment it is considered that access to alternative strategies and resources enhances the resilience of a system by diversity. So, in this regard all

the companies tend to use less virgin materials and to shift towards regenerative or recycled resources in order to contribute to this diversity. But despite this believes, still many companies utilize heavily non-renewable options especially fossil fuels. In order to increase a system's resilience there is a stringent need to provide ways in which a material can circulate for longer in consecutive cycles of repair, reuse, refurbish, remanufacture, and recycle.

The successful implementation of the circular economy depends on efficient management of material flows, the governance of these will have to be decentralized in certain instances, such as food, energy and waste, as well as repair and maintenance services (Dufourmont, Papú Carrone, Haigh, 2020).

The transition to the circular economy requires a set of transferable skills such as customer service, creating solutions, developing critical thinking, solving problems and assessing risks that consistently arise as sectors adapt their business models and see increased needs for business models such as servitisation (Dufourmont, Papú Carrone, Haigh, 2020). Comparing the education distribution of employed people in Moldova across all economic activities and in the category of industry, it is evident that workers with a vocational education profile are more likely to find job opportunities in energy sector. By contrast, the share of workers with a low level of education is lower than in the overall employed population. This suggests, as expected, the need for a skilled workforce (Chilari, Gribincea, 2021). Therefore, developing a workforce with ample transferable skills contributes to resilience by creating surplus in labor and skills supply. Further, circular transition should be underpinned by a culture of lifelong learning, as such directly contributing to resilience. As the transition to the circular economy continuously develops, so do the related skills requirements. For this reason, a culture of lifelong learning should be promoted as part of the circular economy in Moldova.

It is to be considered that circular economy tends to focus on economic and environmental impacts such as resource depletion, resource efficiency, innovation rates and air pollution. Important slow social variables to the circular economy have not received sufficient attention globally, and Moldova is not an exception. It includes legal systems, behaviors, value systems and traditions. Moldova need to develop circular economy governance systems as well as the currently variable indicators.

6. Conclusion

Managerial practice focuses largely on performance management. But because the Covid-19 pandemic has revealed the painful fragility of many of our systems, leaders are focusing on resilience; and with the loss of biodiversity, climate action and sustainable resource management should be a priority in the recovery phase. Sustainable management of natural resources, including smarter use of materials, has many benefits: it reduces the rate of depletion of natural resources. It generates opportunities, including low material supply dependencies and economic diversification towards resilient business models with a circular economy and jobs. Lower input levels help reduce waste streams and emissions and reduce costs for producers and consumers. In addition, it stimulates innovation, the creation of new industries and stimulates economic competitiveness.

It can be stated that there are a multitude of synergies between resilience thinking and the circular economy. According to Dufourmont, Carrone, Haigh (2020) several circular economy trends increase resilience. In cycling resources, the circular economy increases resilience by increasing the diversity of feedstocks; in sharing resources, it increases

resilience through localized management and participation of stakeholders; and decentralized activities and infrastructure increase resilience by bringing governance bodies closer to communities, enhancing broader participation and moving away from the hyper specialization that characterizes the linear economy.

The circular economy can contribute to the sustainability of the environment by redesigning industrial organizations and internal life as a whole, relying mainly on the school of ecology that makes a deeper and more sustainable transformation in order to reduce the impact of human activities on the environment through the intelligent reuse of waste.

The fundamental goal to be pursued is to rethink manufacturing systems and to intervene in the way of consumption through technological, social and organizational innovation with a global involvement of several stakeholders. Under the new approach, products will be characterized by a longer shelf life, at the end of which the resources that made it up will have to be reused in new manufacturing cycles to create new value, which will drastically reduce waste production.

For the implementation of a circular economy, the starting point is a new design of manufacturing processes, products and services to ensure longer product durability, simple repairs, the possibility of modernization, mass recycling of components and raw materials before the end of life of life. Thus, the whole value chain should be revised, from the use of raw materials, to the technological innovation applied to production, to the development of efficient distribution systems, to a more responsible use of the product, to its recycling, which has a significant effect. on all elements of the value chain; the use of raw materials by providing recycled materials and natural resources, changes the manufacturing processes and the distribution chain and, finally, contributes to the determination of a longer product life.

Therefore, there is a need for strong innovation-based change and focus, capable of technological, organizational, behavioral and regulatory change, and to design new business-to-consumer models in the medium to long term. Implementing a circular economy model requires the involvement of society and businesses to achieve zero waste, zero urban emissions and material recycling practices.

Acknowledgement*: The article was developed within the framework of Subprogram 030101 „Strengthening the resilience, competitiveness, and sustainability of the economy of the Republic of Moldova in the context of the accession process to the European Union”, institutional funding.*

References:

1. Barnes, J.H.Jr., 1982. Recycling: A problem in reverse logistics. *Journal of Macromarketing*, 2(2), pp.31–37.
2. BiO3, 2021. *Circulytics 2.0: a new tool of the circular economy.* Available at: <https://bio3consultoria.com.br/en/circulytics-platform-2-0/>.
3. Bocken, N.M., Short, S.W., Rana, P. and Evans, S., 2014. A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production*, 65, pp.42–56.
4. Briones, E., 2021. *Luxe et résilience - Prix Turgot du meilleur livre collectif - 2022: Les clés pour rebondir face aux crises*. French Edition, DUNOD.

5. Butler, J. and Hooper, P., 1999. Optimising recycling effort: An evaluation of local authority PCW recycling initiatives. *Sustainable Development*, 7(1), pp.35–46.
6. Camilleri, M.A., 2018. *The circular economy's closed loop and product service systems for sustainable development*.
7. Chilari, V., Gribincea, C., 2021. Skills for smart specialisation in Moldova - Understanding and managing skills as a key resource for growth and competitiveness, ETF, 2021. Available at: <https://www.etf.europa.eu/en/publications-and-resources/publications/skills-smart-specialisation-moldova-understanding-and>.
8. Cooper, T., 1999. Creating an economic infrastructure for sustainable product design. *Journal of Sustainable Product Design*, 8, pp.7–17.
9. Dufourmont, J., Papú Carrone, N., Haigh, L., 2020. *Resilience & The Circular Economy- Opportunities & Risks.*
10. Geyer, R., Kuczenski, B., Zink, T. and Henderson, A., 2016. Common misconceptions about recycling. *Journal of Industrial Ecology*, 20(5), pp.1010–1017.
11. Ghisellini, P., Cialani, C. and Ulgiati, S., 2016. A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114, pp.11–32.
12. Ho, S., 2020. *Circulytics: New Tool Helps Companies Measure & Track Circularity*.
13. Kennedy, S. and Linnenluecke, M.K., 2022. *Circular economy and resilience: A research agenda (2022).*
14. Kick, M., Kadner, S., Greiff, K., et.al., 2021. Making the circular economy count. acatech/SYSTEMIQ, München/London.
15. Liu, Q., Li, H. M., Zuo, X. L., Zhang, F. F. and Wang, L., 2009. A survey and analysis on public awareness and performance for promoting circular economy in China: A case study from Tianjin. *Journal of Cleaner Production*, 17, pp.265–270.
16. McDonald, S., Oates, C., Thyne, M., Alevizou, P. and McMorland, L.A., 2009. Comparing sustainable consumption patterns across product sectors. *International Journal of Consumer Studies*, 33(2), pp.137–145.
17. Mont, O.K., 2002. Clarifying the concept of product–service system. *Journal of Cleaner Production*, 10(3), pp.237–245.
18. Murray, A., Skene, K. and Haynes, K., 2017. The circular economy: An interdisciplinary exploration of the concept and application in a global context. *Journal of Business Ethics*, 140(3), pp.369–380.
19. Pollex, J., 2017. Regulating consumption for sustainability? Why the European Union chooses information instruments to foster sustainable consumption. *European Policy Analysis*, 3(1), pp.185–204.
20. Reeves, M. and Whitaker, K., 2020. *A Guide to Building a More Resilient Business*.
21. Shrivastava, P., 1995. The role of corporations in achieving ecological sustainability. *Academy of Management Review*, 20(4), pp.936–960.

22. Suárez-Eiroa, B,, Fernández, E. and Méndez, G., 2021. *Integration of the circular economy paradigm under the just and safe operating space narrative: Twelve operational principles based on circularity, sustainability and resilience*.
23. The Ellen MacArthur Foundation, 2025. *Home*. Available at: <https://ellenmacarthurfoundation.org/resources/circulytics/overview>.
24. UNEP, 2006. *Circular economy: An alternative model for economic development. United Nations Environment Programme*. Paris, France. Available at: <http://www.unep.org/resourceefficiency/Portals/24147/scp/nap/circular/pdf/prodev-summary.pdf>.
25. Zhang, Y., Ren, S., Liu, Y. and Si, S., 2017. A big data analytics architecture for cleaner manufacturing and maintenance processes of complex products. *Journal of Cleaner Production*, 142, pp.626–641.