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**CHARACTERISTIC DIFFERENCES OF FUNCTIONING OF LINEAR AND
CIRCULAR MODELS OF ECONOMY**

The article identifies characteristic differences in the functioning of the linear and circular economy. The necessity of replacing the existing linear model of the economy, which is based on the principle of "produce - use - utilize" with a circular one, the basic principle of which is the 3R approach - "reduce, reuse, recycle". The consequences in both the short and long term of the continuation of functioning of the linear model of the economy are revealed. The genesis of the concept of circular economy formation, in particular the concept of efficiency economy, biomimicry, industrial ecology, blue economy is investigated. Characteristic differences between linear and circular economy, as well as between eco-efficiency and rethought eco-efficiency are determined. SWOT-analysis of the implementation of the circular model of the economy was conducted. The advantages of the transition from a linear to a circular economy are identified, simultaneously the barriers to the transformation of the world economy to a circular economy model are highlighted.

Key words: linear economy, circular economy, economic model, concept, environment, eco-efficiency, rethought eco-efficiency

Statement of the problem. The modern economic system "produce - use - utilize" has functioned for a long time at the expense of cheap and affordable raw materials to create conditions for growth and stability. However, by 2030, the number of middle-class consumers is expected to increase by 3 billion people. Such an unprecedented increase in demand for limited supply of resources calls into question the continued functioning of the traditional linear economic system.

Thus, the cost of recycling equipment can be reduced by about 50% if companies produce products that are easy to disassemble, introduce reverse logistics processes and offer incentives to return unnecessary equipment. Also, the distribution of leasing services among households will save about a third per cycle of use, while producers would earn about a third more profit.

The economic benefit of saving materials alone is estimated at more than 1 trillion dollars per year. The transition to innovative reuse, overproduction and recycling of products can lead to significant job creation. In the EU alone, recycling creates 500,000 job places.

The transition to a closed-loop economy will have a positive economic impact on companies and consumers in both industrialized and developing countries. According to the International Trade Union Confederation, such a transition will allow governments around the world to overcome a global job shortage of 600 million people. The circular economy will

allow Ukraine to conserve resources, increase their efficiency, reduce pressure on the environment, promote economic growth, innovate, and more.

Analysis of recent research and publications. Special attention should be paid to the theoretical developments of leading foreign experts, in particular: Bea Johnson, Catherine Whitman, Dave Cheshire, Duncan Baker-Brown, Dustin Benton, Emanuele Bompan, Janine M. Benyus, Kate Raworth, Ken Webster, Marcel den Hollander, Marcello Tonelli, Michael Braungart, Peter Lancey, Roberta de Angelis, Walter Steele, Wesley Spindler, et al.

In addition, among the domestic researchers should be noted the works of I. Buryak, M. Vovk, Zh. Deriy, S. Mashchenko, O. Oliynyk, Yu. Orlovskaya, E. Orlovsky, O. Sergienko, T. Yakovyshyna, et al.

The aim of the article is to establish the characteristic differences in the functioning of linear and circular models of the economy.

Results of the research. As of today, the most fundamental, complex and systemic problem is the question of the foundations, construction and principles of economics. The natural environment is approaching a turning point, when the ability to maintain the biosphere as it is known will be lost. The traditional linear economic model, which functioned perfectly in conditions of abundance of resources, can no longer function fully, as resources are running out and they are not enough to meet all the needs of mankind in modern conditions [2].

Therefore, the concept, or system, of a circular economy is proposed for maximum preservation of the added value of goods and the elimination of waste accumulation. When a commodity completes its life cycle, it remains in the economy as a resource that can be used productively over and over again, creating further value [7]. Demand for raw materials mainly prevailed in industrialized countries, and was satisfied in the world market. Resources were cheaper than labor, so preference was given to a model that relied on the widespread use of raw materials and savings in human labor. In addition, the more resources were used to supplement human capital, the greater the competitive advantage the country received. A natural consequence of cheap raw materials and expensive labor has been the general neglect of recycling, reuse and the accumulation of waste. The result of such actions was the formation of a traditional model of linear economy, the essence of which is the principle of "produce - use - dispose" ("take - make - dispose") [4].

Based on empirical data and economic modeling, researchers from the Ellen MacArthur Foundation have quantified some of the costs of a linear economic model. The statistical material for this was the report of the Research Institute for Sustainable Development of Europe (SERI), which states that 21 billion tons of raw materials used in production are not included in the final product (ie lost during the transition between forms of materials produced as unused by-products due to inefficiency, storage problems, etc.). According to Eurostat, the material contribution to the European economy in 2010 amounted to 65 billion tons, of which 2.7 billion tons were disposed of as waste, only 40% of which was reused in any form (for example, by recycling, reuse or composting). Undistributed waste not only lost its original function, but was wasted as a source of energy [4].

The state of operation of the linear model has also been worsened by a number of trends. The demographic development of mankind has shifted the concentration of population from traditionally densely populated industrialized countries to developing countries. This trend, combined with the rapid economic development of China and India, increases the global mass of middle-class consumers by about 3 billion with corresponding consumption, which is projected to cost 3 trillion dollars infrastructure investment per year. If this level of investment is not reached, it will limit supply. This is especially true in Western economies, which are already operating at almost maximum capacity, such as in the food sector [4].

1. Overproduction. Many products are marketed in large batches, but not all are eventually sold. This leads to surplus stocks on which companies lose money.

2. Reduction of life cycles. Accelerated production and consumption lead to proportional waste generation. Similarly, the introduction of new models of a particular device and the so-called planned aging, in particular in the case of technological goods, means that the previous version will soon become obsolete. Although it brings short-term income to companies, it also has a negative effect on consumers' purchasing power.

3. Accumulation of waste. Accelerated life cycles provoke the unrestrained accumulation of waste, which in many cases harms the environment. A clear example of this is plastic, a material that is not necessarily part of the product itself, but its packaging. These wastes contribute to global warming and climate change.

4. Depletion and overexploitation of natural resources, which leads to an increase in the value of these resources. This is especially true for raw materials such as minerals and fossil fuels [4], reuse, recycle.

Researchers from the Ellen MacArthur Foundation believe that the circular economy should be considered as a basis and a general concept, based on several more specific approaches, guided by a number of basic principles.

The origin of the concept of a circular economy can be traced to the work of American scientist Kenneth Boulding, who in 1966 first proposed a cyclical ecological system instead of a linear economic model that depletes the planet's raw materials. Although Boulding's cyclical economic scheme was rather vague, it stimulated further conceptual development of the issue of sustainability.

In 1982, the Swiss architect Walter Stechel introduced the concept of a spiral loop (or closed loop) of self-replenishment of the economic structure, which he later developed to the idea of economics of "efficiency."

Firms must sell the result, as, for example, in the recently shared business model of the sharing economy. The Stechel concept was incorporated in 2008 into the work of German chemist Michael Braungart and American designer William McDonagh's "cradle-to-cradle", which views any product as one that should receive a second life through technical or biological processing.

The next aspect of the formation of the concept of circular economy is biomimicry. This concept was proposed in 1998 by the American naturalist writer Janine Benyus and was that the economic system should follow the processes of nature's circulation to overcome industrial and commercial challenges, as well as measure the outcome of such activities [1].

The interpretation of the concept of circular economy also uses the scientific approach of industrial ecology, which is associated with the flow of energy and resources in industrial systems, which try to close in a closed cycle to minimize waste. The concept of natural capitalism aims to create a common economic platform that recognizes the needs of both the environment and capital. The main provisions of natural capitalism are:

- the creation of a closed cycle of production for the reuse of non-degradable materials;
- increasing the efficiency of resources to increase their availability;
- "consumer" on the model of "flow of services", not "sale and use";
- quantification of the cost of natural resources to promote reinvestment in nature [1].

economics, a term in economics relating to the exploitation and conservation of the marine environment. Another element of the circular economy is the blue economy, a term in economics for the exploitation and conservation of the marine environment. The concept of the blue economy expands the ideas about the use of waste: outside the internal closed

production cycles, the waste of one industry should be considered as a potential raw material for other sectors of the economy.

The more the industry reuses and recycles its waste, the closer it gets to the idea of a circular economy and the less harmful it is to the environment. The circular economy, in its view, mainly helps to reduce the use of primary raw materials and the use of "clean" technologies, which in turn leads to the minimization of losses from raw materials [1].

In the English-language scientific literature, there are such terms as "eco-efficiency" and "eco-effectivity", which are equally translated into Ukrainian as "eco-efficiency". However, the essence of these terms is significantly different, as the first of them (eco-efficiency) is to minimize the impact on the environment with the same level of production and inherent in the linear model of the economy, so it is proposed to leave it translated as "eco-efficiency". While the second (eco-effectivity) means not just minimizing the impact on the environment, but maximizing the positive impact on the ecological, economic and social state, and is inherent in the circular model of the economy, so it is proposed to call it "rethought eco-efficiency" (table 1.1).

Table 1 Comparison of models of linear and circular economy

| Criteria | Linear model | Circular model |
|---|-----------------------------------|---|
| Scheme of operation | "Produce - use - dispose" | "Reduce, reuse, recycle" |
| The principle of impact on the environment | Eco-efficiency | Rethought eco-efficiency |
| Cycles of model | Short-term, from purchase to sale | Long-term, multiple life cycles |
| Reuse | Downcycling | Upcycling, cascading, high quality processing |

Source: compiled by the author according to the Ellen MacArthur Foundation

Eco-efficiency seeks to reduce the negative effects of production and consumption, while rethought eco-efficiency and the cradle-to-cradle model focus on developing products and industrial systems that maintain or improve the quality and productivity of resources over subsequent life cycles. They provide a practical basis for building products and industrial systems in a positive relationship with environmental well-being and long-term economic growth.

The main difference between eco-efficiency and rethought eco-efficiency is reuse. In a linear economy, reuse is mainly practiced in the form of downcycling: recycling waste, where recycled material has lower quality and functionality than the source material, which reduces the value of the material. This makes it difficult to reuse the material the next time you use it [1].

In a circular economy, reuse is at a higher level. The residual flow is reused to produce goods of the same quality, or even higher. This ensures that the value of the material is maintained or increased.

The use of raw materials in a linear economy is inefficient, as there is no emphasis on its preservation, unlike the circular model, where this is the main focus. In addition, other business models are involved, especially those that focus on services rather than goods, such as the Product as a Service system, which integrates them into a single entity. This principle is followed by Xerox, which provides its printers to other companies free of charge and charges for the number of copies made. This system fits well into the circular economy model, as the manufacturer is interested in ensuring the durability of the printer through the possibility of its

repair and upgrade. In a linear sales system, a manufacturer usually wins if a product fails quickly because it is possible to sell a new one [3]. The circular economy provides better waste management, recyclable resources, profitable companies, and a more sustainable environment.

However, awareness of this issue is still controversial, and interest from governments and organizations remains low. In addition, the model requires a clear regulatory framework for operation, significant investment and research [6].

The above and a number of other issues are presented in the SWOT-analysis of the circular economy model as opposed to the linear (table 2).

Table 2 SWOT-analysis of the implementation of a circular model of economy as opposed to a linear one

| Strengths | Weaknesses |
|---|--|
| <ul style="list-style-type: none"> - the use of the reverse flow of resources is a potential competitive advantage; - the elimination of waste from the value chain has a quantitative benefit, reducing systemic and direct material costs and reducing dependence on resources; - R&D on the main aspects of the circular economy gives impetus to progress in the field of materials science and the development of better and more durable components; - due to closed processes, the economy is less susceptible to fluctuations in raw material prices, and the cost curve eventually equalizes; - reduction of raw material costs reduces dependence on external factors. | <ul style="list-style-type: none"> - circular economy still requires the integration of all processes of the product life cycle, - there is no clear algorithm for implementing the model in different sectors of the economy; - there is still no international institution that would regulate the functioning of this model; - there is still no special legislation on the circular economy and its application; - insufficient investment to implement the circular economy model. |
| Opportunities | Threats |
| <ul style="list-style-type: none"> - by reducing the level of raw materials needed, the economy can save billions of dollars. For example, the EU can save up to \$ 600 billion a year in material costs. - opportunities for the development of new areas to address legal, operational, mechanical, intersectoral issues. | <ul style="list-style-type: none"> - if companies are able to fully manage their own waste, it can deal a blow to waste management companies; - management of the entire product life cycle and strong cooperation can lead to the formation of cartels; - controlling all life product cycle, companies can easily cross-subsidize different activities, which can lead to higher prices. |

Source: compiled by the author according to the data provided by Visegrad Journal on Bioeconomy and Sustainable Development

Thus, the transition from a linear to a circular economy is becoming a key challenge of the 21st century. Despite certain advantages of the circular economy, the vast majority of resources and goods used by society remain part of a linear economy. Therefore, it is

important to identify the barriers that exist on the path of transition from a linear to a circular model of the economy, which are as follows:

1. Characteristics of materials. Too often, products contain many different components that are difficult to separate, which is likely to require expensive and complex processing. For example, disposable coffee cups consist of high-quality cellulose fibers with a thin polyethylene coating, which are difficult to separate, so they currently have a low potential to be used in the circulatory system.

2. Processing technologies. The availability of appropriate recycling technologies is one of the key barriers to the transition to a circular economy and directly depends on the characteristics of the materials. It is necessary to assess the availability and readiness of technologies, the state of the current infrastructure, the location of processing technologies, simplicity of processing and costs. For example, for textile waste, there is a grinding technology that is used to produce fibers with a minimum amount of problem residues. While carbon fiber, which is characterized by high quality and strength, will be difficult to implement in the circular system, as processing technology for its reuse is currently not available in the industry.

3. Impact of current disposal on the environment. Current linear management of end-of-life products or materials has a major impact on the environment, especially if they are high in carbon, so it facilitates the transition from a linear to a circular model. If low-carbon, low-energy materials are available, the transition may not be considered first.

4. Organizational issue. Overcoming this barrier is a willingness to change current management processes and practices, which depends heavily on leadership support, organizational culture, and a willingness to try new ideas.

5. The issue of industry and supply chain is related to the readiness to change logistics links, manufacturers' obligations, build and adapt to new infrastructure, solve the problem of storage, processing and distribution of goods for the purpose of transition to a circular model.

6. External factors. These include the availability of subsidies, investment inflows, R&D support, grants, tax incentives, etc., which would stimulate the development of a circular economy model.

7. Public perception may encourage a shift to circularity, especially if the idea is disseminated at the level of government, communities, the media, etc.

8. Regulatory framework. There is a need to test the current regulatory framework to see if it allows the transition from a linear to a circular model. It should include aspects such as health and safety, material handling requirements, taxes and fines, legal requirements, transparency in the value chain, accountability, public health and safety considerations, etc.

9. Economic feasibility. The transition from a linear to a circular model should be financially attractive and profitable [5].

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Conclusions. Thus, linear and circular models of the economy differ from each other in how value is created or maintained. The linear economy traditionally follows the scheme of functioning "to produce - to use - to utilize". This means that raw materials are used to make goods that are used until they are finally disposed of as waste. In this economic system, value is created by producing and selling as many goods as possible. The circular economy follows the 3R approach - "reduce, reuse, recycle." In this model, the use of resources is minimized, reuse of goods and components is maximized, and raw materials left over or extracted from previous goods are reused to high standards.

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Роледерс В.В.

ХАРАКТЕРНІ ВІДМІННОСТІ ФУНКЦІОНУВАННЯ ЛІНІЙНОЇ ТА ЦИРКУЛЯРНОЇ МОДЕЛЕЙ ЕКОНОМІКИ

У статті встановлено характерні відмінності функціонування лінійної та циркулярної економіки. Доведено необхідність заміни існуючої лінійної моделі економіки, яка базується на принципі "виробляти - використовувати - утилізувати" на циркулярну, основоположним принципом якої є підхід 3R - "зменшувати, повторно використовувати, переробляти". Розкрито наслідки як в короткостроковій, так і довгостроковій перспективі впродовження функціонування лінійної моделі економіки. Досліджено генезис концепції формування циркулярної економіки, зокрема концепції економіки ефективності, біомімікрії, промислової екології, блакитної економіки. Визначено характерні відмінності між лінійною та циркулярною економікою, а також між екоефективністю та переосмисленою екоефективністю. Проведено SWOT-аналіз впровадження циркулярної моделі економіки. Визначено переваги переходу від лінійної економіки до циркулярної, водночас висвітлено бар'єри трансформації світового господарства до моделі циркулярної економіки.

Ключові слова: лінійна економіка, циркулярна економіка, модель економіки, концепція, навколишнє середовище, екоефективність, переосмислена екоефективність.

Роледерс В.В.

ХАРАКТЕРНЫЕ ОТЛИЧИЯ ФУНКЦИОНИРОВАНИЯ ЛИНЕЙНОЙ И ЦИРКУЛЯРНОЙ МОДЕЛЕЙ ЭКОНОМИКИ

В статье установлены характерные отличия функционирования линейной и циркулярной экономики. Доказана необходимость замены существующей линейной модели экономики, основанной на принципе "производить - использовать - утилизировать" на циркулярную, основополагающим принципом которой является подход 3R - "уменьшать, повторно использовать, перерабатывать". Раскрыты последствия как в краткосрочной, так и долгосрочной перспективе продолжения функционирования линейной модели экономики. Исследован генезис концепции формирования циркулярной экономики, в частности концепции экономики эффективности, биомимикрии, промышленной экологии, голубой экономики. Определены характерные различия между линейной и циркулярной экономикой, а также между экоэффективностью и переосмысленной экоэффективностью. Проведен SWOT-анализ внедрения циркулярной модели экономики. Определены преимущества перехода от линейной экономики к циркулярной, одновременно освещены барьеры трансформации мирового хозяйства к модели циркулярной экономики.

Ключевые слова: линейная экономика, циркулярная экономика, модель экономики, концепция, окружающая среда, экоэффективность, переосмысленная экоэффективность.