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Research of Eco-Innovations as the Basis for the Sustainable Economic Development: Theoretical Dimensions

The article discusses theoretical dimensions of research of eco-innovations as the basis of the sustainable economic development. The role of eco-innovation is substantiated and the formation of the concept of eco-innovation is studied.

The essence of eco-innovations is defined, with showing their distinction from other categories of innovations. A specific feature of eco-innovations, technologies for renewable energy in particular, is that they require political support and have global market potentials. Eco-innovations cannot be interpreted in a way similar to other innovations (e. g. from the perspective of dual external effects or regulatory effects of pull and push). They need a relevant theory and specific policies. The types of innovations are characterized. The unclear borderlines between various types of parallel innovations are highlighted, which complicates research processes.

Innovations and eco-effectiveness are key components of national and international economic strategies and strategic components of the sustainable development. Innovations increase the effectiveness and profitability of businesses, allowing them to penetrate new markets and expand the existing ones. Hence, being a critical factor behind the sustainable development, innovations promote employment growth, social welfare and better quality of life.

The drivers of eco-innovations are characterized. The contribution of eco-innovations in the sustainable economic development and transformation of the economy in low-carbon or circular one is substantiated. Given that eco-innovations are a process and that the environmental effects of the product lifecycle have to be comprehensible, eco-innovations are very difficult to measure. The most common methods used for this purpose can be grouped in the following way: analysis of surveys; analysis of patents; analysis of digital and documentary resources. Measurement of eco-innovations at various levels, be it company, industry, region country or international level, is a complex and multipurpose problem.

Key words: *climate change, eco-innovations, green innovations, sustainable innovations, sustainability-oriented innovations.*

Introduction. The declining environmental performance and climate change made governments and corporations include the sustainability in their strategies and development programs. The rapid urbanization, the increasing demand for energy

and resources, the environment pollution and the growing scopes of wastes resulting from the industrial revolution are factors deteriorating the problems which solutions are supposed to streamline the transition to the sustainable development. With the importance of the sustainable development

acknowledged at micro- and macrolevel, the scope of research in this field has been rapidly increasing. The interest of many economists is focused on studies of some categories of innovations capable to preserve environmental resources. Ecological innovations and sustainability-oriented innovations, including integration of environmental and social dimensions in products, processes and organizational structures, can have various implications for the sustainability, positive and negative alike.

Literature review. Studies focused on defining the essence and types of eco-innovations were conducted by J. Horbach, C. Rammer, K. Rennings [12]; J. Hojnik, M. Ruzzier [10]; S. Türkeli, R. Kemp [27]; C. S. Meena [20], B. Peyravi, A. A. Jakubavičius [23] and others [1; 17; 19; 25]. The contribution of eco-innovations in economic growth and economic transformations towards low carbon or circular economy was explored by J. Costa [3], C. Fogarassy and D. Finger [6]. B. Harsanto [8], J. Horbach [11]; the drivers of eco-innovations were outlined by C. A. Díaz-García et al. [4]. Given the importance of eco-innovations as the basis for the sustainable economic development, their essence, implementation schemes and significance are yet to be explored.

The article’s objective is to analyze theoretical dimensions of the eco-innovation concept as the basis of the sustainable economic development.

Research results. After Second World War the world was rapidly developing. Using oil, gas, synthetic materials or cheap energy were part of economic expansion plans. Adverse effects of the mass-scale production started to be a research subject at early 70s of the past century. Scientists had to acknowledge and discuss the issues of environmental pollution, climate change, acid rains, toxic wastes, depletion of natural resources, emission of carbon and other greenhouse gases, global warming.

The concept of innovations interpreted as a driver of economic growth has recently been supplanted by the concept of eco-innovations, because the paradigm of economic growth was replaced by the paradigm of sustainable economic growth. The latter prioritizes research of environmental challenges and finding ways of their elimination. The concept of eco-innovations is, therefore, aimed at reducing adverse environmental effects and effective utilization of resources. Being an integral part of eco-innovations, ecological technologies have become a priority due to the increasing concern with environmental problems.

Basically, the concept of eco-innovations should be regarded as a purposeful response on the need to solve the problems of assessment of environmental effects from economic processes, including technological change. The increasing importance of eco-innovations is stressed in analyses of global economic change in the context of steady technological progress, facing climate change, reduction of resources and intention to build up the low-carbon economy [3]. The concept of eco-innovations was explored by researches in various disciplines: economics, sociology, management. Now this term is used as a synonym of environmental innovations [17; 19], green innovations [1], resilient innovations, sustainability-oriented innovations [8; 25], innovations increasing sustainability, and it covers various technologies (e. g. solar or wind energy systems), organizational methods (e. g. methods for prevention of pollution) and services (e. g. electric railways).

An earliest definition of eco-innovations was offered in 1996 by C. Fussler and P. James [7] who believed that eco-innovations was a result of the invention of a new product, process or service creating a value for a user or a company along with drastically reducing the environmental damage. Various definitions of eco-innovations given by researchers are shown in Table 1.

Table 1

Interpretations of the economic category “eco-innovation”

No.	Source / Author	Interpretations
1	OECD, [18]	Eco-innovation leads to a new or significantly improved product (good or service), process, organisational method or marketing method creating environmental benefits, and that such environmental benefits can occur during the production of goods or services, or during the aftersales use of a good or service by the end users
2	Eco-Innovation Observatory (EIO), [5]	Defines eco-innovation as the introduction of a new or significantly improved product, process, organizational change, or marketing method that reduces the use of natural resources and the release of harmful substances
3	J. Hojnik, M. Ruzzier [10]	Eco-innovations can be viewed in three dimensions: technological, organisational or institutional
4	S. Türkeli, R. Kemp [27]	Eco-innovation – entirely new or modified products, processes, techniques or systems that avoid or reduce environmental damage but retain the same use value
5	C. S. Meena et al. [20]	The term “eco-innovation” refers to the development of novel and economically viable goods, processes, systems, services, and design processes that satisfy human needs while reducing the consumption of natural resources and the emission of hazardous chemicals through their existence
6	B. Peyravi, A. Jakubavičius [23]	Eco-innovation is the intersection of economic gain, environmental innovation, and social consciousness

A broadest definition of eco-innovations was made R. Kemp and P. Pearson [13]. According to them, eco-innovations are "...the production, assimilation, or exploitation of a product utilization, manufacturing techniques of goods or services, or practices that are new to the firm or organization and that outputs, throughout its life cycle, in a reduction of environmental risk, pollution, and other negative impacts of resource use (including energy use) compared to similar alternatives". Eco-innovation has been accepted as a specific roadmap for higher efficiency, increasing effectiveness, and supporting competitiveness while having peremptory impacts on society, the environment, and businesses". In this definition, eco-innovations cover all the new processes increasing the effectiveness of resource utilization, and this term is primarily based on overall assessment of environmental advantages and risks.

Eco-innovations cannot be treated in the same way as other innovations (e.g., in terms of double externalities and regulatory push/pull effects). Eco-innovations, in particular renewable energy technologies, require political support and have global market potential.

The present-day research literature lacks a comprehensive theory of eco-innovations. Their contribution can be interpreted from two opposite theoretical perspectives: neoclassical and evolutionary [12; 26]. In the neoclassical approach eco-innovations have the key role in the achievement of environmental sustainability mainly due to their contribution in the technological advancement, which can compensate adverse effects of the depleted natural resources. N. Hazarika and X. Zhang [9] argue that factors like social and economic change, policy institutes and instruments have the important role in the neoclassical theory, stimulating the development and dissemination of eco-innovations. Evolutionists tend to analyze ecological innovations in their dynamic and multidimensional nature, to outline the important role of organizational, social and institutional innovations for the environmental sustainability. The deterministic neoclassical perspective seems as particularly useful for investigating specific features of ecological innovations. On the other hand, evolutionary theories can be applicable for analyses of radical innovations, because they avoid any kind of technological bias and put emphasis on the need to account for social and institutional dimensions [12; 26]. Hence, the neoclassical approach assumes that technological eco-innovations represent the main tool for achieving the environmental sustainability, whereas the evolutionary approach extends the analysis of eco-innovations by combining social and institutional dimensions with technologies.

The increasing environmental consciousness at national and international level has revealed the necessity in a reliable environmental policy obliging

one to reduce environmental problems and adopt more environmentally friendly or clean production technologies. Although eco-innovation studies significantly expanded in the latest decades, and the social and political weight of eco-innovations based on sustainable development could be increased, their impact on the sustainability is yet to be defined.

The increasing importance of eco-innovations in taking strategic decisions in business improves its sustainability. Companies put strong emphasis on the environmental protection by investing in fostering the environmental consciousness. T. C. Kuo and S. Smith assumed that companies can gain a competitive advantage by accounting for conscious attitudes of consumers to the environment and social expectations of the same views in the business sector [15].

C. P. Kiefer et al. argue that eco-innovations are a category of innovations capable to not only bring benefits to users and companies, but to considerably reduce the adverse environmental effect [14]. The development of eco-innovations promotes economic growth and economic transformations towards the low-carbon or circular economy [3; 6]. Besides that, eco-innovations cover technological innovations in energy saving, prevention of pollution, waste treatment, environmental design of products and environmental management. The appearance of eco-innovations aims to decrease the dependence on natural fossil resources discharging hazardous substances throughout the product lifecycle. However, there are two heavy impediments for dissemination of eco-innovations, which need to be eliminated: (i) market uncertainty; (ii) uncertain economic returns on investment.

The Eco-Innovation Observatory (EIO) classifies eco-innovations by four principal groups (Figure 1, constructed by data from [5]).

K. Rennings [24] classifies eco-innovations as technological, organizational and social; by distinguishing eco-innovations not meant for commercialization, the author identifies corporate eco-innovations.

B. Harsanto et al. investigated the correlation between environmental dimensions of product and process eco-innovations [8]. Innovations based on sustainability pertain to the whole process: from resource creation to product making, consumption and recycling. Innovations based on sustainability change the background of competitiveness, the source of differentiation and the nature of consumption on the global scales.

The problems faced in eco-innovation analyses include unclear borderlines between their types. Also, various types of eco-innovations can be developed in parallel, with economic, social and institutional components interacting with each other. A critical factor to be accounted for is normative acts concerned

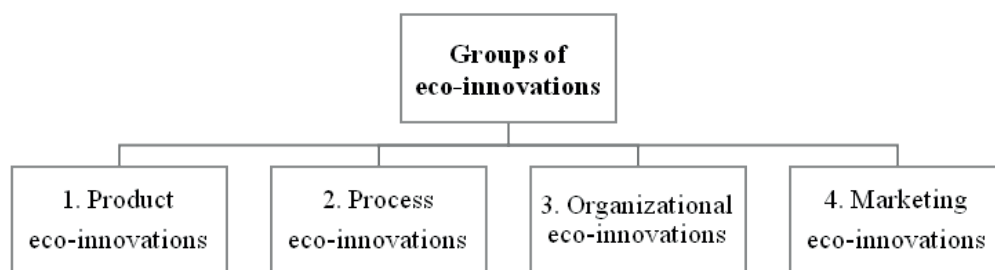


Figure 1. Classification of eco-innovations by the Eco-Innovation Observatory

with not only the environmental dimension. Regulation can also contribute in creating social and institutional innovations, being critically important in implementing the sustainable development model. This requires institutional change combined with strict observation of the rules supporting the sustainable change. Furthermore, social and institutional innovations accompany technological eco-innovations and have impact on the effectiveness of their implementation. Eco-innovations are associated with great many problematic points related with decision-making processes, technological advancements or perceptions of eco-innovations. Innovations and eco-effectiveness are key components of national and international economic strategies, strategic components of the sustainable development, and a critical factor for employment growth, sustainable development, social welfare and better quality of life. There are several reasons for the critical importance of innovations:

- innovations developed as part of the environmental policy often increase the competitiveness by cost reduction and ensure advantages by opening new markets;
- new production processes and technologies, renewable energy systems or infrastructures often require innovations aimed at striking the balance between economic, social and environmental parameters;
- ecological products and processes are part of business operations. Innovations increase the effectiveness and profitability of businesses and allow them to penetrate new markets and expand the existing ones.

A priority objective of eco-innovations is eco-effectiveness, i. e. maximization of the value added in parallel with minimization of resource utilization and environmental effects [21]. Only the development of clean production technologies, waste management and system innovations (new systems of products/services) can ensure the eco-effectiveness, with the final end of increasing the value added and reducing adverse environmental effects.

To achieve the objectives of implementation of eco-innovations, it is necessary to find eco-determinants of innovations. J. Horbach [11] treats supply, demand and technologies as eco-innovation factors.

Institutional and political effects on the supply side cover cost saving, market characteristics, sustainable innovations, risks and biases, level of competencies and other characteristics of the workforce, and the time span. Environmental policies, organizational structures and global pressures are institutional and political determinants [24].

C. Díaz-García et al. divided the drivers of eco-innovations into three categories: micro-level, meso-level and macro-level. The drivers at micro-level cover structural factors, strategy and business logics, resources and capabilities; the drivers at meso-level – market dynamics, finance, networks, groups of pressure and industry; the drivers at macro-level – political instruments, education policy, technological systems and regional variables.

The European Commission on Environmental Technologies determines economic barriers, regulatory barriers and standards, technological barriers and dissemination barriers as main impediments for eco-innovations [2].

The increasing concern of humanity with environmental problems strengthens the emphasis on green technologies as an integral part the innovations [16; 26]. Innovations in green technologies can bring the double benefit: the reduced environmental burden along with the accelerated technological modernization of the economy. Green technologies help strike the balance between the environmental protection and the economic development, which is radically important for creating the sustainable society. It is well known that fighting against climate change and other environmental problems requires far-reaching innovations. This is what green innovations are, as they cover biotechnologies, nanotechnologies, information & communication technologies and environmental technologies [22].

Eco-innovations differ from conventional innovations, as they focus on solving environmental problems in parallel with balancing economic benefits, which requires more initiative for their practical implementation. Research has shown that corporate decision-making, capabilities, efficiency and effectiveness will stimulate the introduction of eco-innovations. It should be noted that the emphasis on achieving environmental goals by the public administration has helped create several behavioral

models, such as the choice of government's behavior or environmental regulation, to encourage corporate eco-innovations.

Conclusions. The uncertain market demand due to inadequate awareness of the essence and the significant impact of eco-innovations on employment and economic growth is an impediment that needs to be eliminated by preparing and implementing an action plan on the promotion of eco-innovations, which components should be:

- creating know-how focused on eliminating the barriers in eco-innovations, innovation activities;
- elaborating and implementing the legislation linking the environment and innovations;
- implementing the projects focused on the enhancement of the environmental performance;
- expanding international cooperation for the promotion of internal and external eco-innovations and mobilization of financial tools, to stimulate eco-innovations across the economy.

The process of economic transformations towards the sustainable development can be accelerated by eco-innovations that help reduce environmental risks, pollution and other adverse effects of resource utilization (including energy resources) compared

with alternatives. Eco-innovations cover a wide range of innovations, such as technologies for renewable energy, systems for prevention of pollution, facilities for waste utilization, green financial products and biological agriculture. Technological innovations have the important social role, as they promote the sustainable economic development and pollution control. The increasing environmental consciousness of the society and pressures from stakeholders make business entities concern with the implementation of eco-innovations, including technological ones.

Theme for further research. Given that eco-innovations are a process and that the environmental effects of the product lifecycle have to be comprehensible, eco-innovations are very difficult to measure. The most common methods used for the measurement can be grouped in the following way: analysis of surveys; analysis of patents; analysis of digital and documentary resources. Because measurement of eco-innovations at company, industry, regional, national or international level is multipurpose, constructing sets of statistical indicators and elaborating technical tools for measurement of eco-innovations requires further detailed research.

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Теоретичні аспекти дослідження екоінновацій як основи сталого економічного розвитку

У статті розглянуті теоретичні аспекти дослідження екоінновацій як основи сталого економічного розвитку. Обґрунтовано роль екоінновацій з неокласичної та еволюційної теоретичних позицій і досліджено становлення концепції екоінновацій.

Визначено сутність екоінновацій та показано, чим вони відрізняються від інших інновацій. Особливістю екоінновацій, зокрема технології відновлюваної енергетики, є те, що вони потребують політичної підтримки та мають глобальний ринковий потенціал. Екоінновації не можна розглядати так само, як інші інновації (наприклад з погляду подвійних зовнішніх ефектів і регуляторних ефектів штовхання/втягування). Вони потребують релевантної теорії та конкретної політики. Охарактеризовано види екоінновацій. Вказано на нечіткі відмінності між типами екоінновацій, розвиток яких відбувається одночасно, що ускладнює процеси дослідження.

Інновації та екоефективність є ключовими компонентами національної та міжнародної економічних стратегій, а також стратегічними компонентами сталого розвитку. Інновації підвищують ефективність і прибутковість бізнесу, дозволяють йому вийти на нові ринки та забезпечують розширення існуючого ринку. Отже, інновації є вирішальним фактором, який сприяє сталому розвитку, а отже, зростанню зайнятості, соціальному добробуту та покращанню якості життя. Виокремлено й охарактеризовано драйвери розвитку екоінновацій. Обґрунтовано роль екоінновацій у сталому економічному зростанні та трансформації економіки в низьковуглецеву або циркулярну.

Зважаючи на те, що екоінновації є процесом і що життєвий цикл продукту повинен бути зрозумілий з погляду виявлення впливу на навколишнє середовище, вимірювання екоінновацій є надзвичайно складним. Найпоширеніші методи, що використовуються з цією метою, можна згрупувати таким чином: аналіз опитування, аналіз патентів та аналіз цифрових і документальних ресурсів. Вимірювання екологічних інновацій на різних рівнях – компанії, галузі, а також регіональному, національному чи міжнародному – є комплексним багатоцільовим завданням.

Ключові слова: зміна клімату, екоінновації, зелені інновації, стійкі інновації, інновації, орієнтовані на сталий розвиток.

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