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EVOLUTION OF THEORIES OF ECOLOGICAL MODERNIZATION AS A MANIFESTATION OF THE INCREASING RISK OF THE INTERNATIONAL ECONOMY: ACTUALIZATION OF SUSTAINABLE BUSINESS PRACTICES IN THE CONDITIONS OF DIGITAL TRANSITION

The purpose of the article is to study the evolutionary changes in modernization theories with an emphasis on theories of ecological modernization as a special direction in the development of economic science. We recognize the digital transition as a trigger for revising approaches to the interpretation of ecological modernization. The hypothesis of the article is based on the assertion that the increased riskiness of the international economy due to the creation of global valuechains and the strengthening of global interconnectedness, global supply chains leads to an asymmetric distribution of the environmental burden between participants in the world economy, which affects the formation of a specific international division of labor - the green international division of labor.

the modernization paradigm of the 1950s and 1960s, which can be called classical, was characterized by focusing research interest on the problems of development, factors and mechanisms of transition from traditionalism to modernity; conducting analysis primarily at the country, national level; operating with endogenous variables, such as social institutions and cultural values; a positive assessment of the modernization process itself as progressive and promising, significantly expanding the potential of human capabilities. The modernization process was viewed as comprehensive, associated with "revolutionary" in significance, radical transformations of models of human existence and activity. The concept of knowledge is characterized by incompleteness, linearity and unambiguous determination, which in itself carries risks. In the modern world, risk begins to be understood as a result of the redundancy of scientific and technological progress. Consequently, within the framework of the theory of ecological modernization, it is accepted as an axiom that the capitalist system contains mechanisms that lead to environmentally friendly activities, and damage to the environment is caused by overexploitation of nature, abuses by the private sector. Social dynamics, which assumes constant modernization, forms a constant interaction of society with various threats and dangers, the result of which are risks. As a result, society itself constantly generates them. They are not a consequence of any exceptional phenomena, but are constantly reproduced in the political, economic, and social spheres of life, and arise as a result of decision-making. The theory of ecological modernization is thus perceived as a model of environmental risk management and political practice that combines direct administrative control and self-regulation, self-restraint in consumption. Ecological modernization is most often defined as a reflexive reorganization of industrial society in an attempt to counter the impending ecological crisis. Ecological modernization in the context of digital transformation is a component of economic reform, which is voluntarily carried out by environmentally and socially responsible businesses. According to the concept of "Industry 4.0", we refer to the "factories of the future" as mechanisms of systemic ecological modernization in the context of digital transformation. In order to maintain material prosperity in modern society, it is important to think together about ecological sustainability as the basis for maintaining life on the planet and about digitalization as the foundation of prosperity.

Keywords: *sustainable development, transformation, risks, environmental crisis, global problems, ecological modernization, developing countries, developed countries, security, energy resources, food security, competitiveness, business model, Industry 4., green technologies, digital waste, sustainability, digitalization, climate neutrality, international economics, theory, economic relations*

JEL Classification *F53; Q1; Q57; P48; R15*

ЕВОЛЮЦІЯ ТЕОРІЙ ЕКОЛОГІЧНОЇ МОДЕРНІЗАЦІЇ ЯК ПРОЯВ ЗАГОСТРЕННЯ РИЗИКОГЕННОСТІ МІЖНАРОДНОЇ ЕКОНОМІКИ: АКТУАЛІЗАЦІЯ СТАЛИХ БІЗНЕС-ПРАКТИК В УМОВАХ ЦИФРОВОГО ПЕРЕХОДУ

Мета статті полягає у дослідженні еволюційних змін у теоріях модернізації з акцентом на теоріях екологічної модернізації як особливого напряму у розвитку економічної науки. Ми визнаємо за цифровим переходом тригер до ревізії підходів до інтерпретації екологічної модернізації. Гіпотеза статті базується на твердженні, що посилення ризикогенності міжнародної економіки внаслідок створення глобальних мереж доданої вартості та посилення глобальної взаємопов'язаності, глобальних ланцюгів поставок призводить до неасиметричного розподілу екологічного навантаження між учасниками світового господарства, що впливає на формування специфічного міжнародного поділу праці – зеленого міжнародного поділу праці. Це, в свою чергу, вимагає впровадження конкурентоспроможних сталих стратегій цифрового розвитку, націлених на зелене економічне зростання і підтримку людино орієнтованих соціальних моделей при дотриманні принципів кліматичної нейтральності і раціонального використання природних ресурсів.

Відзначено, що озеленення економіки зосереджується на таких ключових цілях: збереження та відновлення природного потенціалу шляхом підтримки біологічного різноманіття, захисту екосистем, раціонального використання ресурсної бази та зниження рівня забруднення навколишнього середовища; позитивні соціальні зміни, що полягають у покращенні якості життя людей (як здоров'я населення, так і природних умов життєдіяльності); підвищення темпів економічного зростання завдяки міжнародній співпраці, глобальним інвестиціям та ефективності новітніх технологій.

Акцентовано, що цифровізація призводить до екологічних наслідків у вигляді збільшення споживання енергії та більшої потреби в сировині для електроніки, а також збільшення кількості відходів від електронного обладнання. Перехід до екологічної стійкості зосереджений на збереженні природи та використанні відновлюваних ресурсів без шкоди для навколишнього середовища. Електронні відходи важко переробляти, що призводить до утворення ще більшої кількості відходів.

Сучасні теоретичні моделі екологічної модернізації підкреслюють амбівалентний вплив цифрового переходу на навколишнє середовище. Цифрова трансформація промисловості базується на теоретичних концепціях «Індустрії 4.0», «фабрик майбутнього», включаючи цифрові, розумні та віртуальні фабрики. Вони передбачають цифровізацію всього життєвого циклу продукції, використання цифрових моделей як нових розроблених продуктів, так і виробничих процесів, а також поширення цифрових платформ. Ці концепції базуються на цілому спектрі передових технологій, насамперед віртуальному моделюванні, Інтернеті речей, робототехніці, штучному інтелекті, великих даних, хмарних обчисленнях, прогнозній аналітиці, адитивному виробництві.

Теоретичні моделі екологічної модернізації не ігнорують розгляд передумов і наслідків посилення конкуренції за традиційні промислові регіони з боку нових центрів проривних технологій. Впровадження проривних зелених технологій може підвищити конкурентоспроможність підприємств у тих країнах, уряди яких приєднуються до глобальних зелених ініціатив щодо скорочення викидів або побудови кліматично нейтральної економіки. Цифровізація сприяє екологічності підприємницької діяльності.

Ключові слова: *сталий розвиток, трансформація, ризики, екологічна криза, глобальні проблеми, екологічна модернізація, країни, що розвиваються, розвинені країни, безпека, енергетичні ресурси, продовольча безпека, конкурентоспроможність, бізнес-модель, Індустрія 4., зелені технології, цифрові відходи, сталість, цифровізація, кліматична нейтральність, міжнародна економіка, теорія, економічні відносини*

Introduction. In the history of mankind, scientists have identified a number of ecological crises. The current crisis is often called the "crisis of reducers", since natural reducers no longer have time to clean up man-made waste or are not able to do so at all due to the alien nature of the emitted artificial synthetic substances. Almost simultaneously with the "crisis of reducers", two other ecological stresses are also actively manifesting themselves: thermodynamic and caused by a decrease in the reliability of ecosystems. They are associated with the ecological consequences of energy overproduction in the lower troposphere (greenhouse effect, construction of thermal and nuclear power plants, etc.), as well as the disruption of the natural ecological balance. These ecological crises may possibly be resolved if energy and ecological revolutions can occur. Among the manifestations of the environmental crisis and, in particular, environmental problems are climate change as a result of greenhouse gas emissions, shortage and pollution of fresh water, deforestation and desertification, reduction in biodiversity, population growth and displacement as a result of the aggravation of the problem of climate migration, waste disposal, air pollution, degradation

of soils and ecosystems, chemical pollution, depletion of the ozone layer, urbanization, depletion of natural resources, disruption of biogeochemical cycles, and the spread of new diseases. The above highlights the need to adapt the policy of environmental modernization to take into account new development challenges — the digital transition, which absolutizes the importance of innovation and technological developments, and therefore leads to increased demand for resources. The beginning of the development of a new social paradigm is considered to be the Stockholm Conference on the Human Environment, organized by the UN in 1972. [23]. This conference was the first major conference on environmental issues, but its focus was not only on environmental issues, but also on the overall conflict between the needs of socio-economic development and the need to protect the environment. The Stockholm Declaration, developed following the conference, was the first to mention the term "ecodevelopment", which later became synonymous with the concept of "sustainable development". Modernization theory explained the successes and failures of development solely by internal factors operating in each society, its historical and cultural characteristics and traditions, ignoring the different positions of countries in the global force field of the world economy and politics. The weak positions of most developing countries in the system of international relations predetermined their further lag behind the leaders of technoeconomic progress. The environmental consequences of modernization have the greatest impact on poor countries. The idea of the limits of growth is sometimes challenged from the position of "technological optimism". The impressive achievements of modern scientific and technical thought give rise to the illusion that the progress of science and technology allows us to solve all the problems associated with the limited earth's resources and environmental threats. The search for an answer to the environmental and social problems associated with modernization led to the emergence of the concept of sustainable development.

The review of the literature. The reports of the Club of Rome, which developed the position on the need to slow down the growth and stabilize the planet's population, played a major role in the greening of world consciousness. [16; 18; 19; 29]. In recent years, alternative ecological-economic concepts have emerged. The inability to achieve a radical change in the relationship between the economy and the environment has led to the concept of ecotopia, which calls for a return to nature as quickly as possible, and for the rejection of scientific and technological progress, which only destroys the environment. Ukrainian scientists view modernization policy as a component of development strategies [1; 2; 3; 4; 5; 22] , while recognizing the systemic ecological crisis as one of the reasons for the aggravation of the problem of global asymmetries in economic development [6; 7; 24; 25; 26], and, therefore, recognizing the greening of development as a determining imperative for the consolidation of the social, economic and environmental dimensions of transformations [8; 9; 10; 11; 12; 15]. Scientists [13; 17; 20] argue that risks are integral structural elements of post-industrial civilization.

Despite the existing body of work by authors who prove that a sustainable development strategy cannot be developed based on traditional universal ideas and values, stereotypes of thinking, and therefore it requires the development of new scientific and ideological approaches that correspond not only to modern realities, but also to the proposed prospects for the development of the “society-nature” system, we believe that the issue of environmental modernization in the context of the digital transition requires a revision of established ideas about sustainability as such..

The purpose of the article. Realizing that the increased riskiness of the international economy due to the creation of global networks of added value and the strengthening of global interconnectedness, global supply chains leads to a non-asymmetric distribution of the environmental burden (net-producing countries vs. importing countries), we recognize the digital transition as a trigger for revising approaches to interpreting environmental modernization.

The main material of the article. In the 1970s, the theory of modernization was subjected to the strongest criticism, which turned into its complete denial. The theoretical justifications for the idea of modernization were considered unacceptable. First of all, the nonlinearity and multidimensionality of historical development were emphasized, which is carried out in different ways depending on the starting positions of certain societies and the problems they face. The globalization of the modern world leads to an increase in the number of interconnected results of decision-making or refusal to make decisions, which also leads to an increase in risk, which affects the course of ecological modernization processes. Riskiness is facilitated by an excess of knowledge about risks in society and imperfect methods for countering them. The theory of ecological modernization describes the features of the transformation of a social system in line with environmental requirements, while maintaining a market economy and a democratic political system and without a radical restructuring of society. The theory of ecological modernization arose in the mid-1980s among researchers from the Free University of Berlin. The theory of ecological modernization is associated with U. Beck's concept of "risk society" and is interpreted as a tool for risk minimization [14]. Using the concept of "risk society", the researcher characterizes the specifics of the existence of modern civilization, which evolved to this state from the stage of industrial modernization. He argues that in the era of industrial society, risk was considered as a result of insufficient development of technology and scientific knowledge or the inefficiency of their use. U. Beck [14] proposes the concept of the "second modernity" and claims that the extent of the spread of environmental risks largely depends on the level of development of the country. Often, dangerous production is located in less developed countries, so the threats it poses concern, first of all, the population of these countries, but these threats can boomerang against highly developed countries as well.

At the first stages of the development of the theory of ecological modernization, the authors defined the main effect of ecological modernization in industry, namely, in replacing existing industrial technologies with resource-

saving and less destructive ones for nature, human health and the environment. It should be noted that at the fifth stage, ecological modernization was considered as a natural phase of the development of industrial society into a super-industrial and post-industrial one. It occurs under the influence of economic laws and is characterized by the fact that economic development itself needs to reassess the consequences of humanity's impact on the environment. In organizational terms, the post-industrial economy will consist of a variety of network environments of different purposes and scales. The concept of "ecosystem" was borrowed by economists from biology - along with the concept of "ecology". In the economic context, both terms are usually used in combination, within the ecosystem approach, and are considered as concepts that describe the evolution of the nature of interactions between economic agents, models of their innovative activity and their relationships with the operating environment. Networks can be formed on a variety of unifying principles (geographical, political, production, environmental) and at different levels, from local (within organizations, companies, clusters, science parks) to global, i.e. - wherever stable relationships and joint strategies of participants arise. Greening the economy has several key goals, including: (1) conservation and restoration of natural potential by maintaining biological diversity, protecting ecosystems, rational use of the resource base and reducing the level of environmental pollution; (2) positive social changes, which consist of improving the quality of life of people (both the level of public health and natural conditions); (3) increasing the rate of economic growth due to international cooperation, global investments and the effectiveness of the latest technologies.

We highlight a number of functions of greening the economy: resource-saving; stimulating; limiting; evaluative; organizational; moral and ethical; axiological; motivational; harmonizing; evolutionary. From the standpoint of the theory of ecological modernization, we highlight two functions - stabilizing (ensuring positive dynamics of economic growth by reducing the degree of negative socio-economic consequences) and compensatory (compensation for the harm caused to nature and society through the implementation of various economic and social state projects) (Fig.1) [21].

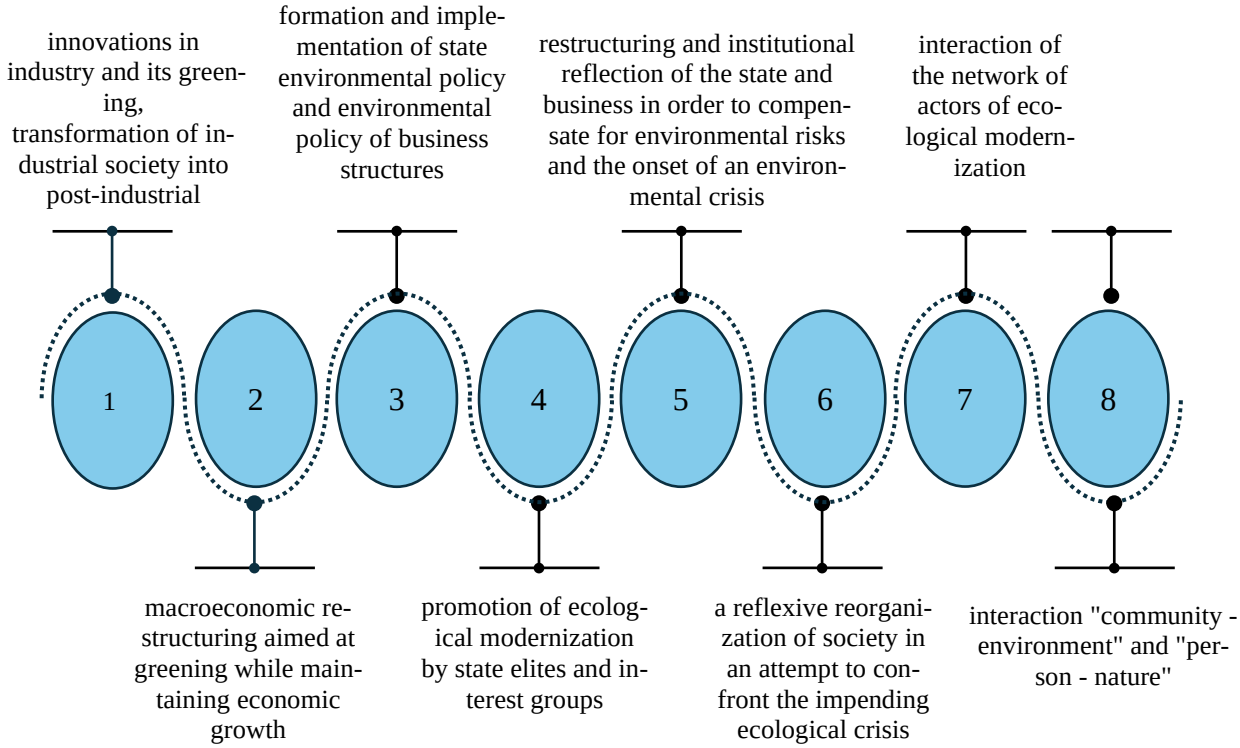

Fig. 1. Evolution of ecological modernization approaches
Source: compiled by the author

The Stockholm Declaration raises the issue of corporate social responsibility, which has led the United States and a number of European countries to initiate appropriate changes in the institutional environment, legislating the need for industrial enterprises to implement environmental protection measures. Despite this, for most companies the environment was important only from the point of view of compliance with the law. But whatever the attitude of manufacturers, they were forced to implement cleaner production. Cleaner production is production that is characterized by the continuous and complete application of an environmental protection strategy to processes and products that prevents environmental pollution in such a way as to reduce the risk to humanity and the environment. With regard to processes, this is the rational use of raw materials and energy, the exclusion of the use of toxic raw materials,

and a reduction in the amount and degree of toxicity of all emissions and waste generated during the production process. In the context of the digital revolution, clean production can be facilitated by the spread of meta- and "supermaterials" with programmable and changeable functional properties, the transition to clean, low- and post-carbon energy, which involves the formation of a new large market for energy storage, the use of flexible smart grids, and distributed generation. The spread of non-traditional methods of material processing (additive manufacturing, atomically precise manufacturing), robotic and automated systems, as well as the scaling of the use of augmented, virtual reality, and artificial intelligence for the purposes of analytics and process control can help reduce environmental risks.

Government actions on environmental modernization are an integral part of innovation policy in industry, and they can mean an attempt to overcome the conflict between economic growth and environmental protection. Focusing on innovation allows us to offer solutions to environmental problems - innovations can make the industry more efficient, so in the future there will be a generation of economic growth, due to which it will be possible to increase funding for green technologies and digital transformations.

Ecological modernization in the context of digital transition assumes taking into account the revolutionary changes in industrial ecology. In various industries, companies are already using digital solutions to create environmental sustainability. However, these solutions primarily serve to increase economic efficiency and only secondarily have a positive impact on the consumption of resources and energy. Therefore, the use of digital technologies is motivated primarily by economic and, to a lesser extent, environmental reasons [27]. Digital technologies themselves must become more environmentally friendly. Since the digital transition, which does not contradict the principles of climate neutrality, is associated with the need to produce global public goods such as environmental and climate security, the question arises whether the pioneering countries in the transformation process will not only bear additional costs, but also gain some competitive advantages over time. The free-rider problem exacerbates the problem of asymmetric distribution of transaction costs and therefore transition risks. This requires additional theoretical research.

Digitalization also leads to environmental consequences, in the form of increased energy consumption and a greater need for raw materials for electronics and an increase in the amount of waste from electronic equipment. The transition to environmental sustainability focuses on preserving nature and using renewable resources without harming nature. Electronic waste is difficult to recycle, which leads to the formation of even more waste that can no longer be recycled and reused. The production of electronic devices involves excessive use of non-renewable natural resources and the production of digital devices consumes a lot of energy. The digital transformation of industry is based on the theoretical concepts of "Industry 4.0", "factories of the future", including digital, smart and virtual factories [28]. They involve the digitalization of the entire life cycle of products (from the concept idea, design, production, operation, maintenance and disposal), the use of digital models (doubles) of both new designed products and production processes, as well as the distribution of digital platforms. These concepts are based on a whole range of advanced technologies, primarily virtual modeling, the Internet of Things, robotics, AI, big data, cloud computing, predictive analytics, additive manufacturing.

The formation of new digital markets is accompanied by the spread of technologies and innovations in production processes, including: equipment and materials for post-carbon energy (distributed generation technologies, new solutions in the field of energy saving, renewable energy sources); new solutions in the field of biotechnology (gene and genome editing technologies, microbiomics, immune system engineering, etc.); new chemistry and new materials (2D materials, development of micro- and nanoencapsulation technologies, self-healing and high-strength lightweight materials, etc.); intelligent equipment and technological systems for advanced manufacturing (new solutions in robotics and automation, nano-production, new technologies in 3D printing — nano-3D printing, 3D printing using biomaterials); next-generation microelectronics and the required component base (non-silicon electronics, quantum communications, quantum computers, photoelectronics, flexible electronics, etc.); new solutions for healthcare and medicine (technologies in the field of surgical robotics, super-high-resolution microscopy, creation of artificial organs, medical and biological informatics, next-generation drugs); new generation of sensor and control and measuring devices (biosensors, "smart" tactile technologies, contactless sensor technologies, etc.); new solutions in the field of information and communication technologies (new media, blockchain, artificial intelligence technologies, machine learning, transition to new generations of mobile communications, etc.).

The uneven development of breakthrough technologies leads to the formation of a new system of geographic centers around leading entrepreneurial universities that unite researchers and developers of breakthrough technologies. This provokes increased competition for traditional industrial regions from new centers of breakthrough technologies. The introduction of breakthrough green technologies can increase the competitiveness of enterprises in those countries whose governments join global green initiatives to reduce emissions or build a climate-neutral economy. Digitalization contributes to the environmental friendliness of business activities, since the costs of moving many goods and services that are traditionally not portable in geographical space are reduced many times over. Goods and services from non-tradable become tradable. First of all, this concerns the areas of education, healthcare, security, as well as other services traditionally provided by the state.

Conclusions. In general, the modernization paradigm of the 1950s and 1960s, which can be called classical, was characterized by focusing research interest on the problems of development, factors and mechanisms of transition from traditionalism to modernity; conducting analysis primarily at the country, national level; operating with endogenous variables, such as social institutions and cultural values; a positive assessment of the modernization process itself as

progressive and promising, significantly expanding the potential of human capabilities. The modernization process was viewed as comprehensive, associated with "revolutionary" in significance, radical transformations of models of human existence and activity. The concept of knowledge is characterized by incompleteness, linearity and unambiguous determination, which in itself carries risks. In the modern world, risk begins to be understood as a result of the redundancy of scientific and technological progress. Consequently, within the framework of the theory of ecological modernization, it is accepted as an axiom that the capitalist system contains mechanisms that lead to environmentally friendly activities, and damage to the environment is caused by overexploitation of nature, abuses by the private sector. Social dynamics, which assumes constant modernization, forms a constant interaction of society with various threats and dangers, the result of which are risks. As a result, society itself constantly generates them. They are not a consequence of any exceptional phenomena, but are constantly reproduced in the political, economic, and social spheres of life, and arise as a result of decision-making. The theory of ecological modernization is thus perceived as a model of environmental risk management and political practice that combines direct administrative control and self-regulation, self-restraint in consumption. Ecological modernization is most often defined as a reflexive reorganization of industrial society in an attempt to counter the impending ecological crisis. Ecological modernization in the context of digital transformation is a component of economic reform, which is voluntarily carried out by environmentally and socially responsible businesses. According to the concept of "Industry 4.0", we refer to the "factories of the future" as mechanisms of systemic ecological modernization in the context of digital transformation. In order to maintain material prosperity in modern society, it is important to think together about ecological sustainability as the basis for maintaining life on the planet and about digitalization as the foundation of prosperity.

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