Marketing and Management of Innovations
Issue 1, 2022

ISSN 2227-6718 (on-line)
ISSN 2218-4511 (print)

https://doi.org/10.21272/mmi.2022.1-17

JEL Classification: H 87, O 13, Q 43

Svitlana Khalatur,
D.Sc., Professor, Dnipro State Agrarian and Economic University, Ukraine
ORCID ID, 0000-0001-8331-3341
email: skhalatur@gmail.com
Olesia Dubovych,
Ph.D., Associate Professor, Poltava State Agrarian Academy, Ukraine
ORCID ID, 0000-0003-3390-1393
email: alesiy.-d@ukr.net

Corresponding author e-mail: skhalatur@gmail.com

FINANCIAL ENGINEERING OF GREEN FINANCE AS AN ELEMENT OF ENVIRONMENTAL INNOVATION MANAGEMENT

Abstract. *Currently, the Ukrainian economy is beginning to implement the concept of «green» finance at the legislative level. But the minimum legal framework is already present to protect the environment of Ukrainians. The management of eco-innovation is essential, as most countries that negatively contribute to the sustainable environment are primarily countries with significant financial shortfalls. The article aims to determine the basic theoretical and practical principles of financial engineering of green finance as an element of environmental innovation management. European countries were selected to study the possibilities of financial engineering of green finance as an element of environmental innovation management. The study period is 2000-2020. The article analyzes and studies the main indicators of energy production and usage, adjusted savings, rent for using natural energy sources, Environmental Performance Index 2020, environmental health indicator, and other indicators for the studied countries. Regarding the possibilities of green financing in Ukraine, the existing normative legal acts are considered. For developing areas for improving the management of environmental innovations, this study was conducted in the following logical sequence: built a multifactor linear regression model net inflows of foreign direct investment; the influence of factors on the performance indicator is determined; the most influential factors for determining the directions of future improvement have been identified. The authors confirmed thAT the financial engineering of green finance is a tool that combines the world of finance, innovation, and business with environmental behavior. It is an activity area for many participants, including individual and business consumers, manufacturers, investors, and financial lenders. Unlike traditional financial activities, green finance focuses on environmental friendliness and pays more attention to the environment. Thus, investing in climate change and clean energy knowledge could better assess risk and return. Two important strategies in global sustainable development are energy efficiency and the development of renewable energy sources. As for the development of renewable energy industries, the main factor hindering the development of industrialization is the lack of capital and an effective financing mechanism.*

Keywords: green finance, innovation, environmental performance, sustainability, financial engineering.

Introduction. Under the growing number of environmental challenges, the key issue is determining what measures are most needed to ensure each country's economy's efficiency, effectiveness, and sustainability so that the financial system can contribute to specific sustainable development priorities.

In this study, financial engineering is defined as the purposeful development and implementation of new financial instruments and/or new financial technologies and the creative search for new approaches to solving financial problems using financial instruments and technologies. Green finance is a structural component of the finances of individual economic entities, which is primarily implemented through the efficient use of natural resources and environmental protection without losing the productive capacity of such entities in the financial system. This component is important in the current stages of human development, as it ensures the latter's future.

Cite as: Khalatur, S., & Dubovych, O. (2022). Financial Engineering of Green Finance as an Element of Environmental Innovation Management. *Marketing and Management of Innovations*, 1, 232-246. http://doi.org/10.21272/mmi.2022.1-17

Received: 20 February 2022 **Accepted:** 25 March 2022 **Published:** 30 March 2022

The article aims to determine the basic theoretical and practical principles of financial engineering of green finance as an element of environmental innovation management based on the results of the analysis of environmental performance using world indexes, energy indicators, and building the multifactor linear regression model.

Literary Review. Green finance as an element of environmental innovation management has been considered in the works of many researchers and scholars.

Versal and Sholoiko (2022) argued that the growth of social welfare and economic development have their price. This price is rising sharply due to environmental problems, leading to a significant shift from the usual understanding of economic development to sustainable development. Therefore, green finance has emerged, one of the tools of which is green bonds. Shkarupa et al. (2021) note that Ukraine is one of the countries facing climate change, and transport is the main source of air pollution in Ukrainian cities. The most acute problem is the lack of a strategic plan to move transport companies to the green course, which requires additional costs and special tools to develop and implement cost-effective solutions to address emissions in the transport sector. Prajapati et al. (2021) noted that the world's biggest challenge is managing the transition to a low-carbon sustainable economy without affecting the speed and diversity of growth. As the diversity of green bonds attracts a diverse investor base, this is a major factor contributing to the rapid expansion of the green bond market. Madaleno et al. (2022) established a causal link between green finance, clean energy, environmental responsibility, and green technology by applying a new test of causation that changes over time. Recursive development and window collapse algorithms show bidirectional causal links between green finance, clean energy, environmental responsibility, and green technologies, but not throughout the period, but with a particular decline and loss of significance during COVID-19. Zhang et al. (2022) argued that the coordination and balance of development between green finance and environmental performance are crucial to ensure sustainable development in an economic transition. Researchers indicated that the industry structures, the level of economic development, and environmental standards positively affect the coordinated development of green finance and environmental performance, while population density slows it down.

Al Mamun et al. (2022) studied the impact of green finance on decarbonization. The authors have shown that green financing significantly reduces carbon emissions in the short and long term. This effect is due to green bonds issued to support waste and pollution control and increase energy efficiency. Gholipour et al. (2022) investigated the relationship between green finance and CO2 emissions from the construction industry. The policy of supporting this development during the COVID-19 pandemic is crucial, as this crisis has limited the availability of «green» funding, which has slowed or canceled any progress.

Lee and Pu (2012) conducted empirical tests from the point of view of financial engineering on the impact of Chinese stock reform (unblocking non-traded stocks) using the case study method and found positive and negative abnormal returns under different conditions. Hermundsdottir et al. (2022) studied manufacturers' reaction to the crisis after COVID-19, particularly how it influenced their adoption of environmental innovations. Researchers are examining whether firms are choosing «general» or «green» strategic responses to the crisis and how this affects eco-innovation implementation.

Humphrey and Li (2021) argued that the weakening of global warming is identified as one of the most acute problems of our time. Zhang and Kong (2022) investigated the impact of green lending policy on investment in enterprise research. Xiang et al. (2022) argued that public companies could obtain the funds needed for green innovation through internal and external financing. The impact of three external financing channels, namely government subsidies, equity financing, and debt financing, on green innovation is gradually weakening. Braga et al. (2021) proved that governments and multilateral organizations could reduce the risk of green investment by supporting green bond issuance as opposed to private green bonds. It shows higher yields, volatility, beta prices, and conventional energy bonds, which are more volatile due to fluctuations in oil prices. Altaghlibi and Wagener (2019) showed that conditional green financing is rarely effective. It is based on the effect of forced interim savings. In some cases, this is ineffective at best and

counterproductive at worst. Hagspiela et al. (2021) indicated that in pursuit of ambitious greenhouse gas reduction targets, many countries had introduced support schemes to accelerate investment in renewable energy. However, this has a serious impact on investment behavior. Thus, environmental degradation may pose risks to financial assets and institutions and the financial system. Here, the main focus in financial policy and regulation should be on understanding the scale of these risks and the introduction of financial engineering of green finance as an element of environmental innovation management.

Methodology and research methods. The methodological basis of the article is a system of methods: analysis and synthesis, comparative, analytical, economic and mathematical, etc. The reliability of the study is based on the use of regulations and fundamental works of scientists. The research hypothesis is that green finance as an element of environmental innovation management is influenced by the following indicators: firms using banks to finance investment; alternative and nuclear energy; renewable energy consumption; adjusted net savings, including particulate emission damage; stocks traded, total value. European countries were selected to study the possibilities of financial engineering of green finance as an element of environmental innovation management. The study period is 2000 - 2020. Countries were selected by income level according to the World Bank classification, namely high-income countries (Austria, Croatia, Denmark, Finland, Latvia, Lithuania, Poland), upper-middle-income country Bulgaria and lower-middle-income country Ukraine. Data for analysis were taken from open sources, particularly World Bank, epi.yale, the Green Finance Measures Database, and United Nations Environment Programme. To develop areas for improving the management of environmental innovations:

- a multifactor linear regression model of net inflow of foreign direct investment was built;
- the impact of factors (the number of firms that use banks to finance investments; alternative and nuclear energy; renewable energy consumption; adjusted net savings, including damage from particulate emissions; traded shares) on the performance indicator (foreign direct investment, net inflow) was determined;
- the most influential factors for determining the directions of future improvement were specified based on the analysis of data from the studied European countries (Finland, Denmark, Austria, Belgium, Lithuania, Latvia, Croatia, Poland, Ukraine, Bulgaria).

To determine the factors to be included in the model:

- pair correlation coefficients were calculated; the correlation matrix was constructed, and its statistical analysis was carried out;
- based on the results of statistical analysis, correlation galaxies were built, and the factors that need to be included in the model will be determined;
- in case of the implicit connection between the signs of factors, partial correlation coefficients should be calculated, and their statistical analysis should be carried out.

The practical significance of the article lies in the possibility of using the findings to create real projects, proposals, and recommendations for the development of green finance engineering in Ukraine and improve the management of environmental innovation, taking into account the experience of European countries**.**

Results. The management of eco-innovation is particularly important, as most countries that make a negative contribution to the sustainable environment are primarily countries with significant financial shortfalls. Table 1 analyzes the main indicators of energy production and uses in the studied countries.

Adjusted savings (AS) measures the real level of savings in the economy, taking into account investment in human capital, depletion of natural resources, and damage caused by pollution. Adjusted savings, informally known as real savings, are an indicator aimed at assessing the economy's resilience based on the concepts of expanded national accounts. Figure 1 analyzes adjusted savings in the studied countries.

Table 1. The main indicators of energy production and use on average for 2000-2020

Indicator	Austria	Belgium	Bulgaria	Croatia	Denmark	Finland	Latvia	Lithuania	Poland	Ukraine
Alternative and nuclear energy, % of total energy use	10,73	20,9	24,61	7,4	5,88	21,37	7,06	23,3	0,42	17,95
CO2 emissions, metric tons per capita	7,97	9,65	6,12	4,78	8,1	10,56	3,45	4,27	7,97	6,28
Combustible renewables and waste, % of total energy	11,43	2,14	4,33	12,7	9,44	19,46	24,5	10,4	5,17	0,68
Electricity production from coal sources, % of total	11,46	9,69	47,16	17,6	43,7	15,56	0,01	0,00	89,6	34,57
Electricity production from hydroelectric sources, % of total	60,70	0,40	7,94	51,9	0,06	18,05	55,5	5,77	1,42	5,90
Electricity production from natural gas sources, % of total	16,16	27,6	4,48	16,9	17,8	13,05	39,1	31,8	2,82	12,02
Electricity production from nuclear sources, % of total	0,00	52,9	37,95	0,00	0,00	30,65	0,00	49,1	0,00	46,32
Electricity production from oil sources, % of total	2,03	0,92	1,00	11,3	2,62	0,67	0,66	4,21	1,59	0,40
Electricity production from oil, gas, and coal sources, % of total	29,65	38,2	52,64	45,9	64,2	29,28	39,8	36,1	94,0	46,99
Electricity production from renewable sources, excluding hydroelectric, % of total	8,85	6,83	1,87	2,06	32,6	14,41	4,49	8,61	4,46	0,25
Renewable electricity output, % of total electricity output	69,55	7,23	9,81	54,0	32,7	32,45	60,0	14,3	5,88	6,15
Renewable energy consumption, % of total final energy consumption	28,96	4,75	12,09	27,6	20,0	34,04	36,1	20,8	8,91	2,34

Sources: developed by authors based on World Bank (2021).

Positive savings allow a country's wealth to grow over time, thus providing future generations with at least as many opportunities as current generations. In this sense, the adjusted savings seek to offer analysts an indicator to track progress in this work. Figure 2 analyzes the studied countries' adjusted net savings, including particulate emission damage.

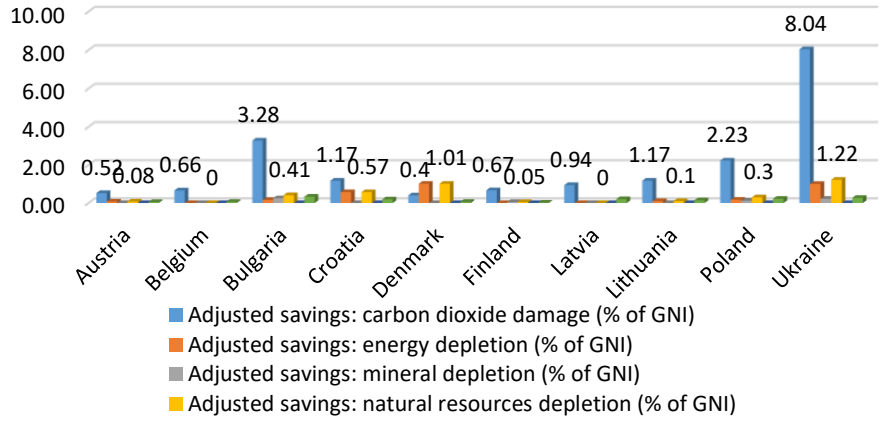

Figure 1. Adjusted savings on average for 2000-2020, % of GNI

Sources: developed by authors based on World Bank (2021).

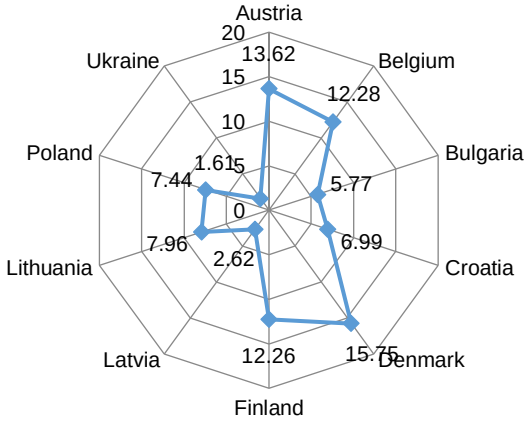

Figure 2. Adjusted net savings, including particulate emission damage, % of GNI

Sources: developed by authors based on World Bank (2021).

Savings are a key aspect of development. Countries could not avoid a state of low subsistence without creating a surplus for investment. Resource dependence makes it difficult to measure savings, as depletion of natural resources is not reflected in standard national accounts. The same applies to contamination or damage to existing assets. Adjusted savings overcome this problem by measuring the change in the value of the specified set of assets. If a country's savings are positive and accounting includes a fairly wide range of assets, economic theory assumes that the value of welfare increases. Conversely, constantly negative adjusted savings indicate that the economy is on an unstable path. In addition to being an indicator of sustainability, adjusted savings have several other benefits as an indicator of policy. This indicator presents resources and environmental issues in financing and development planning. It increases the need to increase domestic savings and, consequently, the need for effective macroeconomic policies. Besides, it covers the fiscal aspects of the environment and natural resource management. It collects fees for resources and taxes for environmental pollution, which are the main ways

to ensure the efficient use of environmental resources. Figure 3 analyzes rent for using natural energy sources in the studied countries.

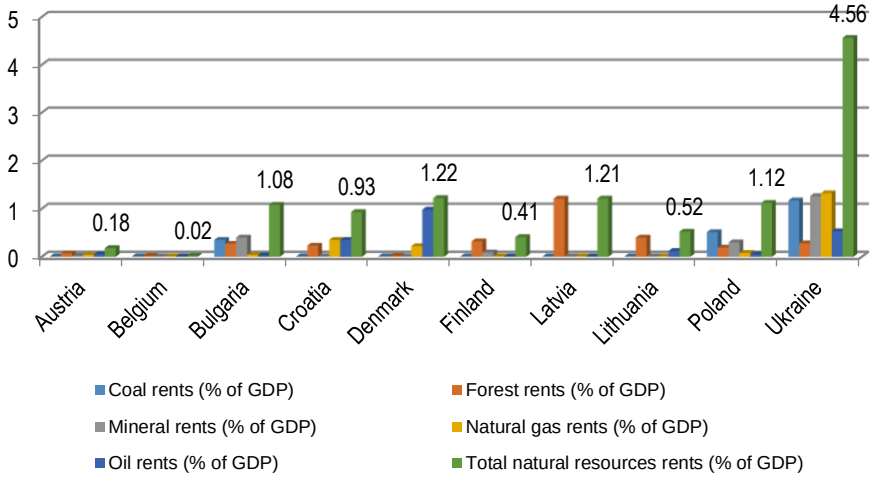

Figure 3. Rent for the use of natural energy sources on average for 2000-2020, % of GDP
Sources: developed by authors based on World Bank (2021).

Another important indicator is the Environmental Performance Index (ERI) – a comprehensive indicator of the environmental policy of the state and its individual actors. The index is calculated by 24 performance indicators in ten categories, covering health, environment, and ecosystem viability. EPI 2020 provides a quantitative basis for comparing, analyzing, and understanding environmental performance in 180 countries. These countries were measured and ranked by environmental indicators and examined how these indicators have changed over the last decade. Figure 4 analyzes Environmental Performance Index 2020 in the studied countries.

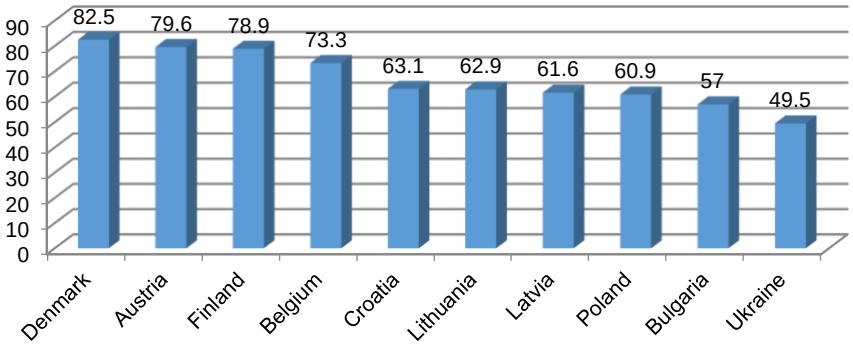

Figure 4. Environmental Performance Index 2020
Sources: developed by authors based on epi.yale (2021).

According to the Environmental Performance Index 2020, among 180 countries, Denmark ranks the first place, Austria – the sixth, Finland – the seventh, Belgium – the fifteenth, Croatia – the thirty-fourth,

Lithuania - the thirty-fifth, Latvia – the thirty-sixth, Poland - the thirty-seventh, Bulgaria - the forty-first, Ukraine - the sixties. The environmental policy aims to determine how well countries protect their populations from environmental risks. It accounts for 40% of the EPI's overall score and consists of four categories of issues: air quality, sanitation and drinking water, heavy metals, and waste management. Figure 5 analyzes Environmental Health Indicators in the studied countries.

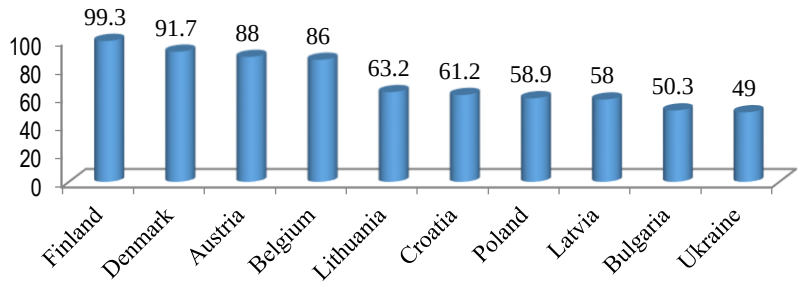

Figure 5. Environmental Health Indicator, 2020

Sources: developed by authors based on epi.yale (2021).

In terms of environmental health in 2020 among 180 countries, Finland is in the first place, Denmark – in the eighth place, Austria - in the sixteenth place, Belgium – in the twentieth place, Lithuania – in the thirty-sixth place, Croatia – in the thirty-seventh place, Poland - in the forty-third place, Latvia - in the forty-fifth place, Bulgaria - in the sixty-third place, Ukraine - in the sixty-ninth place. The air quality category measures the direct impact of air pollution on human health in each country. Noteworthy here, it consists of three indicators: PM2.5 exposure, solid household fuels, and ozone exposure. Figure 6 visualizes the indicator «Air Quality» in the studied countries.

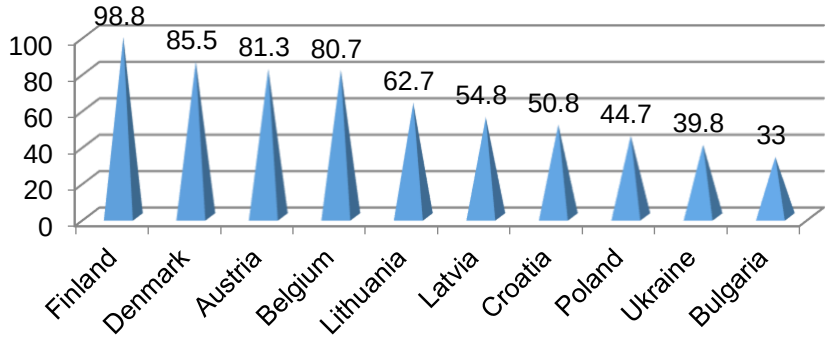

Figure 6. Indicator «Air Quality», 2020

Sources: developed by authors based on epi.yale (2021).

The environmental category of agriculture measures the efforts to maintain a healthy population by minimizing agricultural threats to the environment. It is based on one indicator - the Sustainable Nitrogen Management Index (SNMI). Figure 7 presents the indicator of environmental friendliness of agriculture in the studied countries.

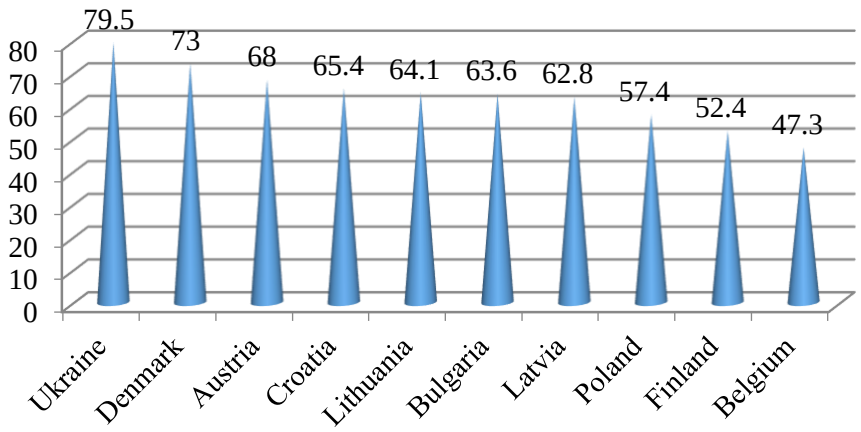

Figure 7. Indicator of environmental friendliness of agriculture, 2020

Sources: developed by authors based on epi.yale (2021).

According to the indicator of environmental friendliness of agriculture in 2020, Ukraine ranks the first place, Denmark – the fifth, Austria – the twelfth, Croatia – the fifteenth, Lithuania – the twentieth, Bulgaria – the twenty-first, Latvia – the twenty-fourth, Poland – the twenty-fourth, Poland - the thirty-second, Finland – the forty-third, Belgium – the fifty-ninth. Infrastructure investment should be increased and integrated with climate risks to prevent development reversals. A shift to low-carbon and climate-friendly infrastructure is required. It requires a mechanism beyond traditional concessional financing to reduce the risks of the structure of financing infrastructure projects into viable and profitable projects.

Using technical assistance for project preparation provided by bilateral and multilateral aid agencies and financial development institutions, creditworthy project sponsors are steadily creating several projects that could be financed. Still, there is a significant gap between eligible opportunities and financial risks. The Green Finance Guarantee Facility would help overcome financial institutions' and credit committees' obstacles in reducing real or perceived risk. Moreover, the green finance guarantee mechanism could attract investment capital to obtain innovative infrastructure projects that have a significant impact on the climate that does not yet have commercial experience. However, although there are financially viable climate-friendly infrastructure projects that have been financially closed, their number is small, and they are assessed based on traditional risk and return profiles. Climate-smart infrastructure projects could be assessed in terms of financial viability from the perspective of economic viability (estimation of project costs (capital, operating, and non-financial costs) compared to project benefits (revenues, non-financial benefits, avoiding environmental costs, increasing productivity, etc.). Climate-friendly infrastructure projects do not have a clear payback model and do not bring investors a profit compared to the market rate of project financing. Therefore, most investments in climate-smart infrastructure do not progress and do not receive financial closure.

To ensure the quality of «green» finance development, it is necessary to identify the main components included in «green» finance. Sources of funding are divided according to the level of the economic system, namely: the national and international levels, considering the interrelationships in solving both social and environmental problems. The local level should be singled out within the national level and beyond the national level, such a regional level as the European region. It determines sustainable development and funding of relevant activities. Table 2 presents the analysis of green finance in the European region: the top investors in the environmental fund in 2021.

Table 2. Green finances in the European region: top investors in the environmental fund in 2021, million US dollars

Country	Green finances, million of US dollars
Netherlands	9,2
Germany	8,8
France	7,5
Belgium	6,1
Sweden	5,0
Denmark	4,9
United Kingdom	4,5
Switzerland	4,0
Norway	3,0
Finland	2,9
Italy	2,7
Spain	1,6

Sources: developed by authors based on The Green Finance Measures Database and United Nations Environment Programme.

Regarding the national level of green finance in Ukraine, it promotes tax reform, tax discipline, and customs regulation. The countries introduce national or local taxes on carbon emissions. In addition, it is necessary to ensure quality management of public finances in the framework of public policy, which concerns the revision and redistribution of expenditures and the direction of public funds to support projects that contribute to the sustainable development of the country's economy. The use of financial instruments by the state becomes equally important, not only in introducing additional taxes to stimulate the reduction of emissions and pollution but also in the state's investment in projects aimed at the active use of technologies that improve the environment. In this context, it is important to have a systematic approach in terms of financial and environmental components by developing tools for the accurate assessment of the level of environmental pollution by a particular economic entity.

As for the role of private investors, it is not limited to the participation of financial intermediaries, such as banks, insurance companies, or private pension funds. Equally important from the point of view of creating conditions for the sustainable development of «green» finance is the role of the population as a potential consumer of environmentally friendly goods created based on «green» means of production. It is actually the creation of demand and hence the formation of the relevant market segment.

Moreover, all the above elements interact with each other and significantly impact the development of «green» finance. Thus, public policy can change the «green» financial tax burden on emissions. Companies can start looking for new technologies to produce environmentally friendly products by increasing the size of the environmental tax. But at the same time, the introduction of new technologies requires funds, and in most situations, the company would attract investment.

The Tax Code of Ukraine, which is the main lever for regulating environmental tax revenues, is important for «green» finances. The following laws are also important for green finance.

The Constitution of Ukraine is the main document that provides the foundation for protecting the country's ecology.

The Law of Ukraine «On Environmental Protection» regulates relations in the field of protection, use, and reproduction of natural resources, environmental safety, prevention and elimination of the negative impact of economic and other activities on the environment, conservation of natural resources, genetic fund of wildlife, landscapes, secondarily affects the activities of the enterprise, namely coordinates such activities in the direction of nature protection.

The Law of Ukraine «On Waste» is a legislative document that regulates the basic conditions, requirements, and rules for environmentally sound management of waste and its disposal and measures related to organizational and economic incentives for resource conservation.

It is important for the company because companies must plan the cost of their financial resources to comply with legal requirements for emissions. The Code of Ukraine «On Subsoil» is an important source of legal information for enterprises engaged in mining in Ukraine and establishes rights and responsibilities for such companies.

The Forest Code of Ukraine is legislation that regulates public relations related to the possession, use, and disposal of forests and aims to ensure the protection, reproduction, and sustainable use of forest resources, taking into account environmental, economic, social, and other factors interests of society. It is important for enterprises that extract wood in raw form for processing and further sale.

The Water Code of Ukraine regulates legal relations on ensuring the conservation, scientifically sound, rational use of water for the needs of the population and industries, reproduction of water resources, protection of water from pollution, clogging and depletion, prevention of harmful effects of water and elimination of their consequences, improvement the state of water bodies, as well as the protection of the rights of enterprises, institutions, organizations and citizens to water use.

The Law of Ukraine «On Basic Principles (Strategy) of State Environmental Policy of Ukraine until 2030» defines the main directions of environmental protection, including the development of economic relations between enterprises in the direction of «green» finance, involvement of international organizations for greening production, the introduction of new rules in production for nature protection.

The Law of Ukraine «On Protection of Atmospheric Air» is a legal basis for enterprises that have emissions into the air (for example, carbon monoxide, carbon dioxide).

The Law of Ukraine «On the permitting system in the field of economic activity»- a law that establishes general rules for obtaining permits by a business entity, for example, licenses for the right to use water bodies, deforestation, mining. Important issues for the company in terms of organizational aspects are license terms, and time lost to obtain such permits, etc.

Almost all of the above legal documents are closely related to the Tax Code of Ukraine (TCU). The TCU establishes taxes and liability for them. Thus, to some extent, all the above laws affect the «green» finances. These finances should be considered a separate component but a component in a set of country factors that affect the environmental situation. That is why all the above legal documents occur in the «green» finance (the above list of documents is not complete). The above laws affect the organizational aspects of the enterprise, i.e., the creation of production under environmental regulations.

The Global Green Finance Index (GGFI) assesses green finance and provides insight into several policies or regulatory market factors that contribute to the growth of green finance. GGFI conducts an international survey of financial professionals to assess the quality and «depth» of green finance development in 110 international financial centers worldwide, combined with an assessment of 131 factors. To develop areas for improving the management of environmental innovations, it is necessary to: build a multifactor linear regression model of net inflows of foreign direct investment; determine the influence of factors on the performance indicator; identify the most influential factors to determine areas for future improvement based on the analysis of data from the studied European countries (Finland, Denmark, Austria, Belgium, Lithuania, Latvia, Croatia, Poland, Ukraine, Bulgaria).

Legend:

X_1 – Firms using banks to finance investment (% of firms);

X_2 – Alternative and nuclear energy (% of total energy use);

X_3 – Renewable energy consumption (% of total final energy consumption);

X_4 – Adjusted net savings, including particulate emission damage (% of GNI);

X_5 – Stocks traded, total value (% of GDP);

Y – Foreign direct investment, net inflows (% of GDP).

Paired correlation coefficients were calculated using the built-in Excel service functions. Table 3 presents a matrix of paired correlation coefficients. The table's cells above the main diagonal are filled in because the table is symmetrical about the main diagonal.

Table 3. Matrix of paired correlation coefficients

Indidicator	X_1	X_2	X_3	X_4	X_5	Y
X_1	1,00					
X_2	0,89	1,00				
X_3	0,56	0,69	1,00			
X_4	0,46	0,66	0,94	1,00		
X_5	0,76	0,71	0,92	0,93	1,00	
Y	0,43	0,63	0,94	0,99	0,87	1,00

Source: developed by authors based on World Bank (2021).

Calculation of the critical value of the correlation coefficient $r_{кр}$ was conducted under the formula as follows:

$$r_{cr} = \frac{t_{\alpha,k}}{\sqrt{t_{a,k}^2+n-2}} \quad (1)$$

where a – level of significance, a = 0,05; $t_{a,k}$ is found using the built-in Excel function. It is received $t_{a,k}$ =2,228. Thus, $r_{кр}$ = 0,56782.

Table 3 is updated. Those elements greater than $r_{кр}$ (this means that the relevant factors are closely related) are highlighted. Table 4 shows the supplemented matrix of paired correlation coefficients.

Table 4.The supplemented matrix of paired correlation coefficients

Indidicator	X1	X2	X3	X4	X5	Y
X_1	1,00	0,89	0,56	0,46	0,76	0,43
X_2	0,89	1,00	0,69	0,66	0,71	0,63
X_3	0,56	0,69	1,00	0,94	0,92	0,94
X_4	0,46	0,66	0,94	1,00	0,93	0,99
X_5	0,76	0,71	0,92	0,93	1,00	0,87
Y	0,43	0,63	0,94	0,99	0,87	1,00

Sources: developed by authors based on World Bank (2021).

Thus, the following factors are closely related:
X_1 та X_2 because r(X_1, X_2)=0,89 >0,56782;
X_2 та X_3 because r(X_2, X_3)=0,69 >0,56782;
X_2 та X_4 because r(X_2, X_4)=0,66 >0,56782;
X_3 та X_4 because r(X_3, X_4)=0,94 >0,56782.
Factor traits are closely related to performance traits Y:
X_2 because r(X_2, Y) = 0,63 >0,56782;
X_3 because r(X_3, Y) = 0,94 >0,56782;
X_4 because r(X_4, Y) = 0,99 >0,56782.
Correlation galaxies are constructed based on the results of the correlation matrix analysis, i.e., a reliable relationship between the factors is shown.

The first correlation galaxy: Y, X_2, X_3, X_4, X_5 indicates that the model should include factors X_2, X_3, X_4, X_5 because they are related (i.e., effect) feature Y. That is, sign X_1 should not be included in the model of all the factor features.

The second correlation galaxy: X_2, X_1, X_3, X_4 indicate that only one of the model's features, X_2, X_1, X_3, and X4, could be included because they are interconnected. However, a very strong (0,94) connection between X_3 and X_4 indicates that a connection may exist between X_2 and X_3. Besides, the connection between X_2 and X_4 could only be a consequence of the X_3-X_4 connection. Otherwise, a connection may exist between X_2 and X_4, and between X_2 and X_3, it may only be the result of an X_3-X_4 connection. Therefore, it may be necessary to include X_2, X_3, and X_4 in the model. For finding it out, partial correlation coefficients were used.

The statistical significance of the model was checked. Therefore, Fcr = 4,96; F> Fcr regression equation is significant, the model is valid at a significance level of 0,05. Table 5 shows the results of correlation and regression analysis of indicators.

Table 5. Conclusion of the results

Regression statistics				
Multiple R	0,97425634			
R-square	0,95162578			
Normalized R-square	0,93176245			
Standard error	2,02167489			
Observations	200			
Analysis of variance				
	df	*SS*	*MS*	*F*
Regression	3	702,2367813	257,714869864,32204	
Balance	10	31,2467316	3,2137832	
Total	13	733,6879123		
	Coefficients	*Standard error*	*t-statistics*	
Y- intersection	5,60471	6,082414	0,816087	
x1	0,04183	0,233646	0,329755	
x2	0,67189	0,055281	0,293596	
x3	0,11809	0,325285	0,027594	
x4	0,06899	0,072958	1,010298	
X5	0,16781	0,106774	0,09834	

Sources: developed by authors based on World Bank (2021).

Thus, the regression equation of dependence of foreign direct investment, net inflows (% of GDP) on alternative and nuclear energy (% of total energy use); renewable energy consumption (% of total final energy consumption); adjusted net savings, including particulate emission damage (% of GNI); stocks traded, total value (% of GDP) has the form:

$$Y=5,60+0,67X_2+0,12X_3+0,07X_4+0,17X_5$$

Thus, if X2 (alternative and nuclear energy) changes by 1% foreign direct investment, net inflows increases by 0,67%; if X3 (renewable energy consumption) increases by 1 %, foreign direct investment, net inflows increases slightly by 0,12%; if X4 (adjusted net savings, including particulate emission damage) is changed by 1 %, foreign direct investment, net inflows increase by 0,07%; if X_5 (Stocks traded, total value) changes by 1 %, foreign direct investment, net inflows increases by 0,17%. Thus, in modern conditions, green finance as an element of environmental innovation management is most influenced by the following indicators: alternative and nuclear energy and stocks traded, total value.

The research hypothesis was partially confirmed. Thus, the green finances of the studied countries as an element of environmental innovation management are influenced by the following indicators: alternative and nuclear energy; renewable energy consumption; adjusted net savings, including particulate emission damage; stocks traded, total value.

So, green finance investments contribute to and correlate with the need for clean energy. This study demonstrates the need to develop a comprehensive policy to strengthen environmental responsibility and green finance by financing green technologies for a successful energy transition and achieving sustainable development goals.

Conclusions. Zhang and Kong (2022) confirmed that the impact of green credit policy on enterprise investment in research and development is determined by market environment, geography, and type of firm, and economic policy uncertainty affects green credit policy.

Humphrey and Li (2021) pointed out two mechanisms to reduce greenhouse gas emissions: access to resources and environmental stakeholders. The research of these scientists echoes the conclusions of this article.

The results of this article resonate with the findings of Xiang et al. (2022) that green innovation is a major driver of economic growth in the new era. However, due to high risk, long cycles, and double externalities, green innovations often require long-term financial support during their development.

This article also coincides with Braga et al. (2021) in determining that a significant increase in green investment is needed to achieve emission targets. However, capital markets to accelerate innovative green investment tend to be limited.

The recommendations of this article also coincide with Altaghlibi and Wagener (2019) in the sense that environmentally motivated aid could help developing countries achieve economic growth while mitigating the impact on emissions.

The findings of this article confirm the recommendations of Hainaut and Cochran (2018) that the transition to a low-carbon and climate-resilient economy requires unprecedented redirection and increased investment and finance to adapt economic and social systems. Compared to these investment needs, tracking current domestic levels of investment has been mixed in both developed and developing countries.

Thus, the financial engineering of green finance is a tool that combines the world of finance, innovation, and business with environmental behavior. It is an activity area for many participants, including individual and business consumers, manufacturers, investors, and financial lenders. Unlike traditional financial activities, green finance focuses on environmental friendliness and pays more attention to the environment. So, investing in climate change and clean energy knowledge could better assess risk and return. Two important strategies in global sustainable development are energy efficiency and the development of renewable energy sources. As for the development of renewable energy industries, the main factor hindering the growth of industrialization is the lack of capital and an effective financing mechanism.

Author Contributions: conceptualization, S. K.; methodology, S. K. and O. D.; formal analysis, S. K.; data curation, S. K.; writing-original draft preparation, S. K. and O. D.; writing-review and editing S. K. and O. D.; visualization, S. K.; supervision, S. K.

References

Al Mamun, M., Boubaker, S., & Nguyen, D. K. (2022). Green Finance and Decarbonization: Evidence from around the World. *Finance Research Letters*, 102807. [Google Scholar] [CrossRef]

Altaghlibi, M., & Wagener, F. (2019). Unconditional aid and green growth. *Journal of Economic Dynamics and Control*, *105*, 158-181. [Google Scholar] [CrossRef]

Braga, J. P., Semmler, W., & Grass, D. (2021). De-risking of green investments through a green bond market–Empirics and a dynamic model. *Journal of Economic Dynamics and Control*, *131*, 104201. [Google Scholar] [CrossRef]

Code of Ukraine «On Subsoil». Retrieved from [Link]

Economic Code of Ukraine. (n.d.). Retrieved from [Link]

Gholipour, H. F., Arjomandi, A., & Yam, S. (2022). Green property finance and CO2 emissions in the building industry. *Global Finance Journal*, *51*, 100696. [Google Scholar] [CrossRef]

Green finance institute (2022). Retrieved from [Link]

Green finance platform. (2022). Retrieved from [Link]

Hagspiel, V., Nunes, C., Oliveira, C., & Portela, M. (2021). Green investment under time-dependent subsidy retraction risk. *Journal of Economic Dynamics and Control*, *126*, 103936. [Google Scholar] [CrossRef]

Hainaut, H., & Cochran, I. (2018). The Landscape of domestic climate investment and finance flows: Methodological lessons from five years of application in France. *International Economics*, *155*, 69-83. [Google Scholar] [CrossRef]

Hermundsdottir, F., Haneberg, D. H., & Aspelund, A. (2022). Analyzing the impact of COVID-19 on environmental innovations in manufacturing firms. *Technology in Society*, *68*, 101918. [Google Scholar] [CrossRef]

Humphrey, J. E., & Li, Y. (2021). Who goes green: Reducing mutual fund emissions and its consequences. *Journal of Banking & Finance*, *126*, 106098. [Google Scholar] [CrossRef]

Khalatur, S., Stachowiak, Z., Zhylenko, K., Honcharenko, O., & Khalatur, O. (2019). Financial instruments and innovations in business environment: European countries and Ukraine. *Investment Management & Financial Innovations*, *16*(3), 275. [Google Scholar] [CrossRef]

Lee, D., & Pu, C. (2012). Methods of Financial Engineering: Strategy on Locking Periods. *Systems Engineering Procedia*, *3*, 119-124. [Google Scholar] [CrossRef]

Li, Z., Tang, Y., Wu, J., Zhang, J., & Lv, Q. (2020). The interest costs of green bonds: Credit ratings, corporate social responsibility, and certification. *Emerging Markets Finance and Trade*, *56*(12), 2679-2692. [Google Scholar] [CrossRef]

Madaleno, M., Dogan, E., & Taskin, D. (2022). A step forward on sustainability: The nexus of environmental responsibility, green technology, clean energy and green finance. *Energy Economics*, 105945. [Google Scholar] [CrossRef]

Prajapati, D., Paul, D., Malik, S., & Mishra, D. K. (2021). Understanding the preference of individual retail investors on green bond in India: An empirical study. *Investment Management and Financial Innovations*, *18*, 177-89. [CrossRef]

Shkarupa, O., Vlasenko, D., Vesperis, S., Treus, A., & Juhaszova, Z. (2021). Strategic management or sustainable decisions in business: A case of greening the transport companies. *Problems and Perspectives in Management*, 19(4), 311-324. [Google Scholar]

Tax Code of Ukraine (n.d.). Retrieved from [Link]

The Law of Ukraine «On Amendments to Certain Legislative Acts of Ukraine Concerning Simplification of Attracting Investments and Introduction of New Financial Instruments». Retrieved from [Link]

The Law of Ukraine «On Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the Period up to 2030». Retrieved from [Link]

The Law of Ukraine «On Environmental Impact Assessment». Retrieved from [Link]

The Law of Ukraine «On Environmental Protection». Retrieved from [Link]

The Law of Ukraine «On Protection of Atmospheric Air». Retrieved from [Link]

The Law of Ukraine «On Waste». Retrieved from [Link]

United Nations Environment Programme. (2022). Retrieved from [Link]

Vasylieva, N. (2019). Improvement of Agricultural Management: Functional Comparative Approach. *Montenegrin Journal of Economics*, 15(1), 227-238. [Google Scholar] [CrossRef]

Velychko, O., Velychko, L., & Ramanauskas, J. (2016). Transformation and development of production-logistics enterprises in Ukrainian agrarian economy. *Management Theory and Studies for Rural Business and Infrastructure Development*, *38*(1), 70-87. [Google Scholar] [CrossRef]

Versal, N., & Sholoiko, A. (2022). Green bonds of supranational financial institutions: On the road to sustainable development. Investment Management and Financial Innovations, 19(1), 91-105. [Google Scholar] [CrossRef]

Water Code of Ukraine. (n.d.). Retrieved from [Link]

World Bank. (2021). Retrieved from [Link]

Xiang, X., Liu, C., & Yang, M. (2022). Who is financing corporate green innovation?. *International Review of Economics & Finance*, *78*, 321-337. [Google Scholar] [CrossRef]

Yale University. (2020). Environmental Performance Index. Retrieved from [Link]

Zhang, D., & Kong, Q. (2022). Credit policy, uncertainty, and firm R&D investment: A quasi-natural experiment based on the Green Credit Guidelines. *Pacific-Basin Finance Journal*, 101751. [Google Scholar] [CrossRef]

Zhang, H., Geng, C., & Wei, J. (2022). Coordinated development between green finance and environmental performance in China: The spatial-temporal difference and driving factors. *Journal of Cleaner Production*, *346*, 131150. [Google Scholar] [CrossRef]

Світлана Халатур, д.е.н., професор, Дніпровський державний аграрно-економічний університет, Україна
Олеся Дубович, к.ю.н., доцент, Полтавська державна аграрна академія, Україна

Фінансовий інжиніринг зелених фінансів як елемент менеджменту екологічних інновацій

В економіці України представлена мінімальна законодавча база щодо захисту навколишнього природного середовища. Імплементація поняття «зелені» фінанси на законодавчому рівні знаходиться на початковому етапі. Авторами наголошено на важливості фунціонування менеджменту екологічних інновацій, оскільки більшість країн, які мають негативний вплив на стійкість навколишнього природного середовища переживають зачний дефіцит фінансових можливостей. Метою статті є визначення основних теоретичних та практичних засад фінансового інжинірингу зелених фінансів як елементу менеджменту екологічних інновацій. Емпіричний аналіз базується на даних виробництва та використання енергії, скоригованих заощадженнь, ренти за використання природних джерел енергії, індексу екологічної ефективності 2020 та інших показниках стану навколишнього природного середовища. Об'єктом дослідження є низка країн Європи. Періодом дослідження обрано 2000-2020 роки. Для визначення можливостей зеленого фінансування в Україні розглянуто наявні нормативно-правові акти. Для розробки напрямків удосконалення менеджменту екологічних інновацій, у ході дослідження було: побудувано багатофакторну лінійну регресійну модель припливу прямих іноземних інвестицій; визначено вплив факторів на результативний показник; виявлено найвпливовіші фактори для визначення напрямків майбутнього удосконалення. За результатами дослідження підтверджено, що фінансовий інжиніринг зелених фінансів є інструментом, який поєднує фінанси, інновації та бізнес з екологічною поведінкою. Ця сфера діяльності актуальна для низки учасників, зокрема, індивідуальних і бізнес-споживачів, виробників, інвесторів та фінансових кредиторів. На відміну від традиційної фінансової діяльності, зелені фінанси спрямовані на екологічні проєкти та заходи з охорони навколишнього природного середовища. При цьому інвестиції в знання про зміну клімату та чисту енергію дозволяють краще оцінити ризики та прибуток. Авторами зазначено, що головними стратегіями сталого розвитку на глобальному рівні є підвищення енергоефективності та розвиток відновлюваних джерел енергії. Встановлено, що дефіцит капіталу та ефективного механізму фінансування є головною перешкодою в розвитку відновлюваної енергетики.

Ключові слова: зелені фінанси, інновації, екологічні показники, стійкість, фінансовий інжиніринг.