DOI: 10.55643/fcaptp.5.70.2026.5342

Uliana Andrusiv
D.Sc. in Economics, Associate Professor, Head of the Department of Finance, Accounting and Taxation, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine;
e-mail: andrusivu@ukr.net
ORCID: 0000-0003-1793-0936
(Corresponding author)

Halyna Kupalova
Candidate of Economic Sciences, Professor of the Department of Environmental Management and Entrepreneurship, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine;
ORCID: 0000-0003-4486-8349

Nataliia Honcharenko
Candidate of Economic Sciences, Associate Professor, Head of the Department of Environmental Management and Entrepreneurship, Taras Shevchenko National University of Kyiv, Kyiv, Ukraine;
ORCID: 0000-0001-9274-9905

Nataliia Spasiv
D.Sc. in Economics, Professor of the Department of Financial Technologies and Banking, West Ukrainian National University, Ternopil, Ukraine;
ORCID: 0000-0003-0797-7220

Nazariy Popadynets
D.Sc. in Economics, Professor of the Department of Tourism, Lviv Polytechnic National University; Dolishniy Institute of Regional Research of NAS of Ukraine, Lviv, Ukraine;
ORCID: 0000-0002-7556-6135

Olga Kneysler
D.Sc. in Economics, Professor of the Department of Financial Technologies and Banking Business, West Ukrainian National University, Ternopil, Ukraine;
ORCID: 0009-0004-1521-923X

Received: 11/09/2026
Accepted: 26/10/2026
Published: 31/10/2026

© Copyright
2026 by the author(s)

This is an Open Access article distributed under the terms of the Creative Commons CC-BY 4.0

ECONOMIC ASSESSMENT OF POLLUTION IMPACT ON FORMATION OF SUSTAINABLE FINANCING STRATEGIES FOR ENTERPRISES

ABSTRACT

The transition to sustainable development requires enterprises to account for the financial consequences of environmental pollution, yet reliable tools for quantifying these consequences remain limited. The purpose of the article is to develop a methodological approach to the economic assessment of the impact of environmental pollution on enterprises' financial indicators and to substantiate sustainable financing strategies on this basis. The approach combines an integral indicator of the impact of pollution on the financial condition of an enterprise, a net present value model adjusted for environmental costs and an environmental risk premium, and regression models of return on assets (ROA) and weighted average cost of capital (WACC) that include environmental variables, together with an environmental risk index and an environmental load coefficient with explicit calculation rules. The article is methodological: the models are specified for application to panel data of enterprises, a procedure for their estimation and diagnostics is proposed, and their use is demonstrated on hypothetical illustrative examples rather than on empirical estimates. The illustrative calculation shows that ignoring environmental costs and risks can turn a project with a positive net present value into a value-destroying one. On this basis, a conceptual approach to forming sustainable financing strategies is proposed, comprising diagnostic, strategic, investment, financial-managerial and communication components, together with a typology of four strategies: environmental transformation, gradual ecologization, environmental improvement and environmental leadership, with criteria for selecting among them based on the terciles of their distribution. Sector-specific recommendations on financing instruments are formulated. The findings provide a methodological basis for integrating environmental parameters into enterprises' financial strategies and investment appraisal.

Keywords: environmental pollution, sustainable financing, financial strategy, return on assets, weighted average cost of capital, environmental risk, net present value, ESG, green finance, enterprise

JEL Classification: G31, G32, Q51, Q56, M14

INTRODUCTION

In the context of growing environmental challenges and the transformation of the global business paradigm toward sustainable development, assessing the impact of environmental pollution on the financial results and strategies of enterprises becomes particularly relevant. Current trends indicate a fundamental shift in approaches to evaluating enterprise performance – from exclusively financial indicators to a comprehensive assessment of the economic, environmental, and social components of activity. This reorientation stimulates businesses to adapt their financial strategies by integrating environmental factors into management decision-making.

Institutional investors increasingly treat the low-carbon transition as an investment priority: in a survey of 200 institutional investors managing USD 8.7 trillion, 98% had set a transition investment objective for their portfolios, and 56% planned to increase transition allocations within the next one to three years (BlackRock, 2023). Issuance of green bonds reached a record USD 575 billion in 2023, while total sustainable bond issuance amounted to USD 939 billion (Gardiner & Freke, 2024). At the same time, the Lancet Commission on pollution and health estimated welfare losses from pollution at

USD 4.6 trillion per year, or 6.2% of global economic output (Landrigan et al., 2018), and the World Bank (2025) puts the economic cost of air pollution alone at nearly 5% of global GDP. In Ukraine, the deterioration of the ecological situation has been shown to reduce life expectancy and worsen the health of the population (Andrusiv et al., 2024). These data confirm the importance of integrating environmental factors into companies' financial strategies.

Despite growing awareness of environmental aspects, most enterprises still face the challenge of quantitatively assessing the impact of pollution on their financial indicators and capitalization. The absence of reliable methodologies for such assessment complicates the formation of effective sustainable financing strategies and does not allow full use of the potential of «green» financial instruments.

LITERATURE REVIEW

Research on the impact of environmental pollution on the financing strategies of enterprises has intensified with growing environmental awareness among investors and stricter requirements for environmental information disclosure. The literature can be grouped into several thematic directions that form the theoretical and methodological basis for understanding the relationship between environmental risks and enterprises' financial strategies.

The theoretical foundations of the relationship between pollution and economic processes are presented by Landrigan et al. (2018), who found that pollution leads to significant economic losses through increased healthcare costs, reduced labour productivity, and degradation of natural resources. Scholtens (2017) justifies the need to integrate environmental risks into financial decisions, arguing that financial institutions cannot ignore environmental problems since they directly affect the long-term profitability of investments. In earlier work, Scholtens (2006) showed that finance can act as a driver of corporate social responsibility, creating incentives for enterprises to behave in a more environmentally responsible way.

The concept of Porter and van der Linde (1995) on the relationship between the environment and competitiveness remains relevant: strict environmental standards can stimulate innovations that fully offset the costs of compliance. This concept was developed by King and Lenox (2002), who empirically identified the loci of profitable pollution reduction at the level of individual enterprises.

A separate strand of research links environmental performance directly to financial outcomes. Konar and Cohen (2001) showed that poor environmental performance is negatively correlated with the intangible asset value of firms, and Al-Tuwaijri et al. (2004) found that good environmental performance is associated with good economic performance. According to the meta-analysis of Busch and Lewandowski (2018), carbon emissions vary inversely with financial performance, while Fan et al. (2017) established a positive relationship between energy efficiency and return on assets for energy-intensive firms. With regard to financing costs, Sharfman and Fernando (2008) demonstrated that improved environmental risk management is associated with a lower cost of capital, and Chava (2014) found that firms with environmental concerns face a higher cost of both equity and debt capital.

Stanescu et al. (2021) proposed a conceptual model for integrating environmental impact into managerial accounting information systems, which allows enterprises to assess environmental risks and their financial consequences more effectively. Ismail et al. (2024) developed quantitative approaches in decision theory to enhance risk assessment strategies, which can be applied to environmental risks.

The role of ESG ratings in forming financial strategies was studied by Avetisyan and Hockerts (2017), who showed that the consolidation of the ESG rating industry and the standardization of ESG assessments can lead to a simplification of complex environmental and social problems. D'Amato et al. (2021) used machine learning to predict ESG scores from fundamental financial ratios, which clarifies the relationship between financial indicators and ESG ratings. Ferro et al. (2025) revealed an imbalance between the aspirational and performance features of ESG ratings, which has important implications for sustainable financing strategies.

Portfolio investment with ESG factors is examined by Chen et al. (2021), who developed a model for optimizing socially responsible portfolios with ESG criteria, and by Jin (2022), who proposed a systematic approach to accounting for ESG risk in decision criteria for optimal portfolio selection. Pedersen et al. (2021) developed the concept of the ESG-efficient frontier, which demonstrates the attainable risk - return trade-off when ESG factors are taken into account. Anquetin et al. (2022) studied the impact of different scopes of carbon emissions on green portfolios, which relates directly to the influence of pollution on investment decisions.

Behavioural aspects of sustainable investing were studied by Bauer and Smeets (2015), who identified the role of social identification in investment decisions, and by Berry and Junkus (2013), who examined socially responsible investing from

DOI: 10.55643/fcaptp.5.70.2026.5342

an investor perspective. Derwall et al. (2011) compared values-driven and profit-seeking social investors, and Dimson et al. (2015) showed that investors can influence corporate behaviour on environmental issues through active ownership, which creates additional incentives for enterprises to develop sustainable financing strategies. Bertolotti (2020) studied risk management in ESG portfolios, and Ouchen (2022) compared the volatility of an ESG portfolio with a market benchmark portfolio. Kapil and Rawal (2023), Alda (2021), and De Spiegeleer et al. (2023) confirm that ESG has become a separate dimension of portfolio allocation. Market evidence points in the same direction: green bond issuance reached a record in 2023 (Gardiner & Freke, 2024), and institutional investors name the low-carbon transition among their key investment priorities (BlackRock, 2023).

Ukrainian research in this field can be grouped into three directions. The first concerns «green» financial instruments and the institutional conditions for their development. Pimonenko and Lushyk (2017) analysed the EU experience of green investing and the prospects for its transfer to Ukraine; Chygryn et al. (2018) substantiated green bonds as an incentive for cleaner production at the government and corporate levels, and Pimonenko et al. (2018) considered green entrepreneurship an integral part of the convergence of the national economy. Andrusiv et al. (2026) examined how ESG factors shape investment strategies and securities trading in the context of sustainable finance for Ukrainian enterprises. These works identify the instruments and the participants of the green finance market, but evaluate them mainly at the market and state level, without quantifying how the environmental profile of a particular enterprise affects its access to financing and its cost.

The second direction examines the fiscal and financial regulation of environmental management. Labenko et al. (2024) found that environmental taxes in Ukraine remain an ineffective financial instrument, with a share of GDP below the EU level, and used regression analysis to link air pollutant emissions with current and capital expenditures on environmental protection. Samaricheva et al. (2024) showed that the share of the environmental tax in consolidated budget revenues declined in 2019 - 2023 and that incentives for enterprises to introduce clean technologies remain weak, while Vasilyeva et al. (2023) examined environmental taxation as a means of promoting pro-environmental behaviour. Taken together, these studies suggest that under weak regulatory pressure, the financial consequences of pollution for Ukrainian enterprises are transmitted not so much through payments to the state as through the market – via profitability, investor requirements, and the cost of capital – which justifies assessing these channels directly.

The third direction addresses resource efficiency and the modernization of enterprises. Zelinska et al. (2021) compared sustainable development trends in Ukraine and the world, and Kupalova et al. (2025) studied the ecological modernization of production as a prerequisite for the innovative development of industrial enterprises. These works operate at the level of enterprises and sectors, but treat ecological modernization primarily as a technological and innovation task rather than a financial one. Thus, Ukrainian scholarship has made substantial progress in substantiating green financial instruments and regulatory mechanisms, whereas micro-level econometric evidence on the relationship between pollution, profitability, and the cost of capital of Ukrainian enterprises is still lacking.

Nevertheless, the existing studies focus mainly on listed companies and investment portfolios and treat profitability, cost of capital, and investment appraisal separately. A methodological approach that quantifies the impact of pollution on these indicators within a single framework and translates the resulting assessment into a choice of financing strategy for an enterprise is still lacking.

AIMS AND OBJECTIVES

The aim of the article is to develop a methodology for the economic assessment of the impact of environmental pollution on enterprises' financial indicators and to substantiate sustainable financing strategies on the basis of this assessment. The objectives are as follows:

1. To formalize an integral model that links environmental, financial, and sustainable development parameters of an enterprise.
2. To modify the net present value model of investment projects so that it accounts for environmental costs and environmental risk.
3. To specify econometric models of the impact of pollutant emissions on return on assets and on the weighted average cost of capital and a procedure for their estimation.
4. To develop a conceptual approach to forming sustainable financing strategies and a typology of such strategies.
5. To formulate sector-specific recommendations for implementing these strategies.

METHODS

The economic assessment of the impact of pollution on enterprises' financial results is based on the concept of internalizing external effects (externalities), according to which the negative consequences of business activity should be reflected in the financial indicators of the business entity. The theoretical basis includes the externality theory of Pigou (1920) and the theory of social cost of Coase (1960), the concept of total economic value (Pearce & Turner, 1990), stakeholder theory (Freeman, 1984), and the ESG investing paradigm (Eccles et al., 2014; Elamer & Boulhaga, 2024; Useche et al., 2024).

The study relies on three basic models of corporate finance and econometrics; the modifications developed by the authors are presented in the Results section. Investment projects are evaluated with the classical net present value model, which is based on the theory of interest of Fisher (1930):

$$NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t}, \quad (1)$$

where NPV is the net present value of the project; CF_t is the net cash flow in period t; r is the discount rate; T is the planning horizon of the project.

The cost of financing is measured by the weighted average cost of capital, the theoretical foundations of which were laid by Modigliani and Miller (1958):

$$WACC = \frac{E}{V} \cdot k_e + \frac{D}{V} \cdot k_d \cdot (1 - \tau), \quad (2)$$

where E and D are the values of equity and debt capital; $V = E + D$; k_e and k_d are the costs of equity and debt; τ is the corporate income tax rate. For enterprises whose shares are not traded on a stock exchange, the cost of equity cannot be observed directly and has to be estimated by the build-up method or by the CAPM with the betas of comparable listed companies; this introduces measurement uncertainty into WACC that should be taken into account when the results are interpreted.

The relationships between environmental and financial indicators are estimated with the linear multiple regression model:

$$Y_i = \beta_0 + \sum_{k=1}^{K} \beta_k X_{ki} + \varepsilon_i, \quad (3)$$

where Y_i is the financial indicator of enterprise i; X_{ki} are the explanatory variables; $\beta_0, \ldots, \beta_K$ are the coefficients estimated by the ordinary least squares method; ε_i is the random error.

To include environmental factors in these models, the environmental parameters with the greatest impact on financial results were identified from the literature: greenhouse gas emissions in CO_2 equivalent (Busch & Lewandowski, 2018); energy efficiency, i.e. energy consumption per unit of production (Fan et al., 2017); water consumption and pollution of water resources (Irtyshcheva et al., 2023); waste generation and management (Al-Tuwaijri et al., 2004); and the use of chemical substances and their release into the environment (Konar & Cohen, 2001). The environmental costs of enterprises include the costs of complying with environmental legislation, payments for pollution and the use of natural resources, the costs of preventing pollution and eliminating its consequences, and potential environmental liabilities and penalties.

The article is methodological in nature. Its purpose is to specify the models and the procedure for their application rather than to report estimates for a particular sample; the numerical examples in the Results section are hypothetical and serve only to demonstrate the calculations. The models are designed for application to panel data of industrial enterprises, and the following requirements for such an application are proposed.

Sample formation. The population comprises enterprises of pollution-intensive industries (chemical, metallurgical, energy, mechanical engineering and food) that report pollutant emissions to the State Statistics Service of Ukraine and pay the environmental tax. An enterprise is included if it (a) has published annual financial statements for every year of the study period, (b) has reported emissions of pollutants for the same years, and (c) operated continuously over the period without reorganization. For each enterprise, its legal form, region, and listing status are recorded, and the sample should include both listed and non-listed enterprises. The representativeness of the sample is checked by comparing its industry and regional structure and its size distribution with the population. Enterprises located in temporarily occupied territories or in areas of active hostilities are identified separately, since their reporting may be incomplete. The information sources are

DOI: 10.55643/fcaptp.5.70.2026.5342

the financial statements of enterprises, environmental tax declarations, statistical reporting on emissions and waste, the results of environmental inspections and audits, and credit ratings assigned by authorized rating agencies.

Data structure and estimation. Both regression models are estimated on the same enterprise-year panel rather than on averaged data, so that the time variation is preserved and the two models are comparable. For enterprise i in year t, model (6) takes the form $ROA_{it} = \alpha_1 \ln(EM_{it}) + \alpha_2 \ln(TA_{it}) + \alpha_3 LEV_{it} + \alpha_4 \ln(AGE_{it}) + \mu_i + \delta_t + \varepsilon_{it}$, where μ_i are enterprise effects, and δ_t are year effects; model (7) is specified in the same way. Year effects absorb the common shocks of the period - for 2019 - 2023, the COVID-19 pandemic, the energy crisis, and the full-scale war - which simultaneously affect emissions, profitability, leverage, the cost of capital, and credit ratings. The choice between fixed and random enterprise effects is made with the Hausman test, and pooled OLS is used only if the Breusch - Pagan Lagrange multiplier test does not reject the absence of individual effects. Since the age of an enterprise grows by one each year, ln(AGE) is not identified separately from enterprise and year fixed effects and is retained only in the random-effects specification. Standard errors are clustered by enterprise, because repeated observations of the same enterprise are not independent.

Diagnostics. The procedure includes the variance inflation factor (VIF) for multicollinearity, in particular between ln(EM) and the environmental risk index; the Breusch - Pagan test (or the modified Wald test in the fixed-effects model) for heteroscedasticity; the Wooldridge test for serial correlation in panel data; the Jarque - Bera test for the normality of residuals; Cook's distance for influential observations; and the Ramsey RESET test for the functional form. If heteroscedasticity or serial correlation is detected, cluster-robust standard errors are used; if the VIF exceeds 5, the collinear variables are combined, or one of them is excluded. Possible endogeneity – for example, more profitable enterprises can afford more pollution abatement – is addressed by using lagged explanatory variables and, where suitable instruments are available, instrumental-variable estimation. The calculations can be performed in R (plm package), Stata or Python (linearmodels).

RESULTS

Building on the basic models (1) – (3), the authors developed an integral model of the impact of environmental factors and modified the models of net present value, return on assets, and cost of capital so that they take environmental factors into account.

The integral model links the environmental, financial and sustainable development parameters of an enterprise and synthesizes concepts of environmental economics, corporate finance and sustainable development:

$$EFI = \sum_{i=1}^{n} a_i \cdot EP_i + \sum_{j=1}^{m} b_j \cdot FP_j + \sum_{k=1}^{l} c_k \cdot SR_k, \quad (4)$$

where EFI is the integral indicator of the impact of environmental pollution on the financial condition of the enterprise; EP_i are environmental parameters of enterprise activity (levels of pollutant emissions, intensity of natural resource use); FP_j are key financial indicators (profitability, liquidity, financial stability); SR_k are sustainable development indicators, including social and managerial aspects; a_i, b_j, c_k are weight coefficients that reflect the relative importance of each parameter in the overall impact.

Because the indicators in model (4) are measured in different units, they are normalized before aggregation: stimulants (indicators whose growth improves the condition of the enterprise) as $\tilde{x}_j = (x_j - x_j^{min})/(x_j^{max} - x_j^{min})$, and destimulants (for example, emissions and environmental payments) as $\tilde{x}_j = (x_j^{max} - x_j)/(x_j^{max} - x_j^{min})$, where the minimum and maximum are taken over the analysed set of enterprises or over industry benchmarks. After normalization, all components take values from 0 to 1, and a higher value of EFI corresponds to a lower financial vulnerability of the enterprise to environmental factors. The weights a_i, b_j and c_k are non-negative and sum to one; they can be set equal (by default), determined by the entropy weight method from the variation of the indicators, or established by expert pairwise comparison (the analytic hierarchy process). The sensitivity of the ranking of enterprises to the choice of weights should be checked.

After normalization, the integral indicator is intended to allow enterprises with different environmental profiles to be compared and changes in their financial vulnerability to environmental factors to be monitored over time; its discriminating power should be verified empirically when it is applied to a particular set of enterprises. In contrast to the classical model

$$NPV_{env} = \sum_{t=0}^{T} \frac{CF_t - EC_t}{(1+r+\lambda)^t}, \quad (5)$$

where NPV_{env} is the net present value adjusted for environmental factors; CF_t is the cash flow in period t; EC_t are environmental costs in period t; r is the base discount rate; λ is the environmental risk premium; T is the planning horizon of the investment project.

To avoid double counting, the two adjustments in model (5) capture different components of environmental risk. EC_t is the expected value of environmental costs: planned payments for pollution and resource use, compliance and abatement costs, and probability-weighted expected fines, damages, and remediation liabilities. The premium λ reflects only the residual systematic risk that cannot be diversified and is not captured by the expected cash flows – for example, the risk of tightening carbon regulation and rising emission prices, which is correlated with the general economic situation. If all environmental risks are fully reflected in the expected cash flows, $\lambda = 0$; conversely, a risk included in λ is not included in EC_t.

The effect of the modification can be shown with an illustrative calculation. Consider a hypothetical investment project with an initial investment of UAH 50 million, annual cash flows of UAH 15 million over five years, annual environmental costs of UAH 2 million, a base discount rate of 12% and an environmental risk premium of 3 percentage points reflecting the systematic risk of tightening carbon regulation. The classical model (1) gives NPV = UAH 4.07 million, so the project appears acceptable. Taking into account only the environmental costs reduce the value of the project to UAH −3.14 million; taking into account only the risk premium reduces it to UAH 0.28 million, and model (5) with both factors gives NPV_{env} = UAH −6.42 million. Thus, ignoring environmental costs and risks overstates the value of the project by UAH 10.49 million and may lead to financing a project that destroys value once environmental liabilities materialize. In this example, environmental costs have the stronger effect, which means that investments reducing EC_t directly increase the value of the enterprise's projects.

The regression model of return on assets specifies the general model (3) for profitability and includes the volume of pollutant emissions as the environmental factor:

$$ROA = \alpha_0 + \alpha_1 \cdot \ln(EM) + \alpha_2 \cdot \ln(TA) + \alpha_3 \cdot LEV + \alpha_4 \cdot \ln(AGE) + \varepsilon, \quad (6)$$

where ROA is return on assets, %; EM is the volume of pollutant emissions, tons; TA is the total assets of the enterprise; LEV is financial leverage (the debt-to-assets ratio); AGE is the age of the enterprise, years; α_0 is the intercept; $\alpha_1, \dots, \alpha_4$ are regression coefficients; ε is the random error.

Since the cost of financing is central to the choice of a financing strategy, the impact of environmental factors on the weighted average cost of capital was estimated with a second model:

$$WACC = \gamma_0 + \gamma_1 \cdot \ln(EM) + \gamma_2 \cdot R_{eco} + \gamma_3 \cdot \ln(TA) + \gamma_4 \cdot LEV + \gamma_5 \cdot C_r + \varepsilon, \quad (7)$$

where $WACC$ is the weighted average cost of capital, which reflects the average cost of equity and debt financing; R_{eco} is the index of the environmental risk of the enterprise; C_r is the credit rating of the enterprise; γ_0 is the intercept; $\gamma_1, \dots, \gamma_5$ are regression coefficients; the other variables are as defined above.

The environmental risk index R_{eco} in model (7) is constructed so as not to duplicate the volume of emissions, which enters the model as a separate variable. It aggregates the indicators listed in Table 1, normalized in the same way as in model (4), with equal weights (or with weights determined by the entropy method) and takes values from 0 (minimum risk) to 1 (maximum risk). Before estimation, the correlation between R_{eco} and ln(EM) and the VIF are checked; if they are high, the components most correlated with emissions are excluded from the index.

Table 1. Components of the environmental risk index R_{eco}. Note: the sign "+" means that growth of the indicator increases environmental risk.

Component	Indicator	Direction	Data source
Regulatory compliance	Environmental fines and penalties, % of revenue	+	Financial statements; inspection reports
Burden of environmental payments	Environmental tax and pollution charges, % of revenue	+	Tax declarations; financial statements
Hazardous waste	Share of hazardous waste (hazard classes I - III) in total waste generated	+	Statistical reporting on waste
Environmental incidents	Number of recorded accidents and violations per year	+	Inspection reports; non-financial reports
Environmental management	Absence of a certified environmental management system (ISO 14001): 1 - absent, 0 - present	+	Certification registers; non-financial reports

DOI: 10.55643/fcaptp.5.70.2026.5342

Since the article is methodological, the models are not estimated on a particular sample. Table 2 summarizes the expected signs of their parameters and their theoretical justification; these signs form the hypotheses to be tested when the models are applied to empirical data.

Table 2. Expected signs of the parameters of models (6) and (7). Note: "–" means that the variable is not included in the model.

Variable	Model (6), ROA	Model (7), WACC	Theoretical justification
ln(EM)	–	+	Environmental payments and abatement costs reduce profit; regulatory and reputational risk raises the return required by investors and creditors (Busch & Lewandowski, 2018; Chava, 2014)
R_{eco}	-	+	Higher environmental risk increases the risk premium (Sharfman & Fernando, 2008)
ln(TA)	+	–	Economies of scale; larger enterprises have lower default risk and better access to capital
LEV	–	+	Interest expenses reduce return on assets; higher leverage increases financial risk (Modigliani & Miller, 1958)
ln(AGE)	±	-	Accumulated experience may raise efficiency, while older equipment may lower it
C_r	-	–	A higher credit rating lowers the cost of debt

Table 3 illustrates the application of model (6) to three hypothetical enterprises with different levels of emissions and debt load. The parameter values are illustrative and consistent with the expected signs in Table 2: $\alpha_0 = 12.0$, $\alpha_1 = -1.5$, $\alpha_2 = 0.9$, $\alpha_3 = -4.0$ and $\alpha_4 = -0.3$.

Table 3. Illustrative calculation of ROA using regression model (6). *(Source: authors' calculations for hypothetical enterprises with illustrative parameter values)*

Enterprise	Industry	EM, tons	TA, UAH million	LEV	AGE, years	ln(EM)	ln(TA)	ln(AGE)	ROA, %
A	Chemical industry	120	80	0.45	12	4.79	4.38	2.48	6.21
B	Energy	90	100	0.35	8	4.50	4.61	2.08	7.38
C	Food indus-try	60	60	0.25	6	4.09	4.09	1.79	8.01

Enterprise A (chemical industry), which has the highest emissions and debt load, has the lowest estimated return on assets (6.21%). Enterprise B (energy) occupies an intermediate position (7.38%), and Enterprise C (food industry), with the lowest emissions and leverage, has the highest estimated return on assets (8.01%). This ranking shows how the model translates differences in emissions and leverage into differences in profitability; the figures are illustrative and are not empirical estimates. With $\alpha_1 = -1.5$, a 10% increase in emissions changes ROA by $-1.5 \times \ln 1.1 = -0.14$ percentage points.

Based on the proposed models, a conceptual approach to forming sustainable financing strategies for enterprises is proposed (Figure 1).

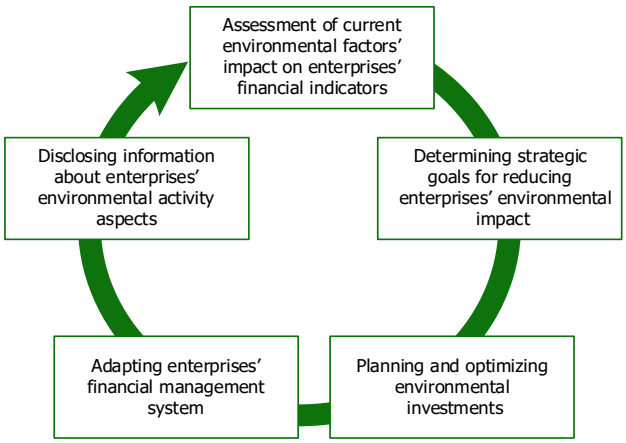


Figure 1. Conceptual approach to forming sustainable financing strategies for enterprises.

The conceptual approach includes five components:

1. Diagnostic component – assessment of the current impact of environmental factors on financial indicators.
2. Strategic component – determination of strategic goals for reducing environmental impact.
3. Investment component – planning and optimization of environmental investments.
4. Financial-managerial component – adaptation of the financial management system.
5. Communication component – disclosure of information about environmental aspects of activity.

The components form a closed management cycle (Figure 1): the results of the communication component and the reaction of investors and creditors become input data for the next diagnostic stage. The content of each component and its link to the proposed models are as follows.

The diagnostic component is the entry point of the cycle. The environmental parameters of the enterprise (emissions, energy and water consumption, waste) are combined with its financial indicators in the integral indicator (4), and models (6) and (7) are used to estimate how much profitability the enterprise loses and how much more it pays for capital because of its environmental load. For example, with the illustrative value $\alpha_1 = -1.5$, model (6) implies that a 20% reduction in emissions raises ROA by about 0.33 percentage points ($-1.5 \times \ln 0.8 = 0.33$). The output of this stage is the environmental load coefficient of the enterprise and its position in the distribution of this coefficient among comparable enterprises.

The strategic component translates the diagnosis into targets. On the basis of the environmental load coefficient and the impact on ROA, the type of sustainable financing strategy is selected (Figure 2, Table 4), and target values for emissions, energy intensity, and waste are set together with the corresponding financial targets for ROA and WACC over a planning horizon of three to five years.

The investment component selects and finances environmental projects. Projects are ranked by NPV_{env} according to model (5); projects that are acceptable under the classical model (1) but have a negative NPV_{env} are revised or rejected, while projects that reduce environmental costs EC_t or the risk premium λ receive priority. The sources of financing are matched to the selected strategy.

The financial-managerial component adapts the financial management system: environmental costs and reserves are included in budgets, environmental indicators are added to the key performance indicators of managers, and the capital structure is optimized. According to corporate finance theory and the expected signs of α_3 and γ_4 (Table 2), financial leverage both reduces ROA and increases WACC; therefore, enterprises with a high environmental load should finance modernization primarily with long-term, target-oriented instruments rather than by increasing short-term debt.

The communication component covers the disclosure of environmental information to investors, creditors, and other stakeholders. It is theoretically expected that transparent environmental reporting reduces the environmental risk perceived by investors and creditors and supports the credit rating, which, given the expected signs of γ_2 and γ_5 in model (7), would lower the cost of capital. Model (7) does not contain a disclosure variable; therefore, this effect is a hypothesis to be tested by adding a disclosure indicator to the model rather than a result of the present study. Disclosure is also a prerequisite for access to green bonds and sustainability-linked loans.

Depending on the level of impact of pollution on financial indicators and on industry specifics, four types of sustainable financing strategies are distinguished (Figure 2).



Figure 2. Sustainable financing strategies for enterprises.

DOI: 10.55643/fcaptp.5.70.2026.5342

1. Environmental transformation strategy – for enterprises with a high environmental load and a significant negative impact on financial indicators; it involves a radical change in technological processes and the business model.
2. Gradual ecologization strategy – for enterprises with a medium environmental load; it is oriented toward the phased introduction of environmentally clean technologies and practices.
3. Environmental improvement strategy – for enterprises with a low environmental load; it is aimed at optimizing existing processes and introducing environmental management systems.
4. Environmental leadership strategy – for enterprises that seek competitive advantages through environmental factors; it involves a proactive approach to managing environmental aspects and to innovation in sustainable development.

The environmental load coefficient of an enterprise is calculated as the ratio of its total environmental costs to net revenue, $K_{EL} = EC/R$, where EC is the sum of the environmental tax and pollution charges, current environmental protection costs, environmental fines, and depreciation of environmental protection assets for the year, and R is net revenue. The coefficient shows the share of revenue absorbed by environmental costs; it is calculated from financial statements and environmental tax declarations and is comparable across enterprises of different sizes.

The choice between the strategies is based on two quantitative criteria obtained at the diagnostic stage: the environmental load coefficient and the impact of environmental factors on ROA. Fixed threshold values are not universal, so they are set from the distribution of the criteria in the analysed set of enterprises (an industry or a national sample) using terciles. Enterprises in the upper tercile are assigned to environmental transformation, those in the middle tercile to gradual ecologization, and those in the lower tercile to environmental improvement (Table 4). The expected ROA loss is calculated with model (6) as the difference between the ROA predicted at the enterprise's actual emissions and at the median emissions of the analysed set. If the two criteria place an enterprise in different terciles, the more demanding strategy is chosen.

Table 4. Criteria for selecting a sustainable financing strategy.

Strategy	Environmental load coefficient	Expected ROA loss (model 6)	Typical industries	Priority financing instruments
Environmental transformation	upper tercile	upper tercile	Metallurgy, chemical industry	«Green» bonds, long-term loans of international financial institutions, environmental insurance, reserve funds
Gradual ecologization	middle tercile	middle tercile	Energy, mechanical engineering	Sustainability-linked loans, leasing, carbon financing, phased investment loans
Environmental improvement	lower tercile	lower tercile	Food industry	Own funds, microfinance, grant programmes, energy service contracts
Environmental leadership	any level	-	Enterprises with certified environmental management and ESG disclosure	«Green» and sustainability-linked bonds, equity of ESG investors

Given the usual pollution intensity of production, metallurgical and chemical enterprises are typically expected to fall into the environmental transformation group, energy and mechanical engineering enterprises into gradual ecologization, and food enterprises into environmental improvement; the actual assignment, however, depends on the values of the criteria for a particular enterprise. The environmental leadership strategy is not tied to a particular level of load: it is the target state toward which an enterprise moves as its load decreases, and it can be chosen by any enterprise that is ready to use its environmental performance as a competitive advantage. As the environmental load declines, an enterprise moves along the sequence transformation - gradual ecologization – improvement – leadership, and the range of financing instruments available to it widens.

The implementation of these strategies covers four areas: financial resource management («green» budgeting, environmentally oriented financial planning, optimization of the capital structure with regard to environmental risks); investment activity (criteria for the environmental assessment of investment projects, formation of an environmental investment portfolio, attraction of financing for environmental projects); risk management (identification and assessment of environmental risks, measures to minimize them, their integration into the general risk management system); and information disclosure (an environmental reporting system, integration of environmental indicators into financial reporting, communication with investors and other stakeholders).

Combining the typical environmental profiles of industries with the typology of strategies makes it possible to formulate sector-specific recommendations for implementing sustainable financing strategies:

1. For chemical and metallurgical enterprises (typically the environmental transformation strategy) – an environmental insurance system and special reserve funds to cover environmental risks, an environmental control system, and «green» bonds and long-term loans of international financial institutions to finance large-scale modernization; given the sensitivity of WACC to financial leverage, short-term borrowing should not be used to finance environmental projects.
2. For energy enterprises (typically gradual ecologization) – diversification of energy sources with an emphasis on renewables, an energy management system, carbon financing mechanisms, and environmental certification of products; financing should be phased and linked to emission reduction milestones, for example through sustainability-linked loans.
3. For mechanical engineering enterprises (typically gradual ecologization) – ecodesign of products, a product life cycle management system, leasing for the introduction of environmentally clean technologies and an environmental audit system; leasing allows modernization without a substantial increase in financial leverage.
4. For food industry enterprises (typically environmental improvement) – environmental certification and labelling of products, closed production cycles, microfinancing of environmental projects and a waste management system; since the environmental load of such enterprises is usually low, these measures can be financed mainly from own funds, microfinance and grant programmes.

For all industries, investment projects should be screened with model (5), and the effect of the measures should be monitored through the integral indicator (4) in the next cycle of the conceptual approach.

DISCUSSION

The negative relationship between emissions and return on assets assumed in model (6) is consistent with the meta-analytic evidence of Busch and Lewandowski (2018) and with the findings of King and Lenox (2002) on profitable pollution reduction, and it supports the argument of Porter and van der Linde (1995) that environmental improvement and competitiveness are compatible. The emphasis on energy efficiency among the environmental parameters agrees with Fan et al. (2017), who found a positive relationship between energy efficiency and return on assets.

The expected signs in the cost of capital model (7) follow from theoretical expectations that environmentally inefficient enterprises face higher financing costs because of reputational risks, regulatory pressure, and limited access to capital. They are in line with Sharfman and Fernando (2008) and Chava (2014), who documented a higher cost of equity and debt for firms with weaker environmental profiles, and with the growing role of ESG criteria in capital allocation (Alda, 2021; De Spiegeleer et al., 2023; Kapil & Rawal, 2023). Konar and Cohen (2001) showed that the market penalizes poor environmental performance, which supports including environmental risk in the required return. Taken together, the literature indicates that environmental load can be a significant determinant of both profitability and the cost of capital, and that it should be considered when a financial strategy is formed under tightening ESG regulation.

The proposed approach differs from previous research in several respects. First, most empirical studies of the link between environmental and financial performance use samples of listed companies in developed markets and market-based measures such as firm value, stock returns or the implied cost of equity (Konar & Cohen, 2001; Chava, 2014; Busch & Lewandowski, 2018). The proposed methodology relies on accounting indicators and environmental reporting, which makes it applicable to enterprises in an emerging economy, such as Ukraine, that have no stock market valuation.

Second, previous studies analyse either profitability (King & Lenox, 2002; Fan et al., 2017) or the cost of capital (Sharfman & Fernando, 2008; Chava, 2014) separately. The proposed framework specifies both indicators for the same enterprise-year panel, which makes it possible to test whether pollution affects the financial position of an enterprise through two channels at once: lower return on assets and a higher cost of capital. If confirmed, this dual effect would strengthen the economic argument for environmental investment, because a reduction in emissions would simultaneously increase returns and reduce the cost of financing.

Third, existing conceptual models integrate environmental impact into managerial accounting (Stanescu et al., 2021) or relate financial ratios to ESG scores (D'Amato et al., 2021), but do not provide a tool for investment decisions. The integral model (4) and the modified net present value model (5) proposed here fill this gap; the illustrative calculation shows that ignoring environmental costs and risks can turn a seemingly profitable project into a value-destroying one.

Fourth, Ukrainian studies focus mainly on financial instruments and state regulation at the macro level (Pimonenko & Lushyk, 2017; Chygryn et al., 2018; Labenko et al., 2024). This study moves the analysis to the level of the enterprise and

DOI: 10.55643/fcaptp.5.70.2026.5342

links the choice of financing instruments to a quantitative assessment through explicit criteria for selecting a strategy (Table 4).

Accordingly, the scientific novelty of the study consists in the following: the methodological approach to the economic assessment of the impact of pollution on enterprises' financial indicators has been improved by combining the integral indicator, the environmentally adjusted net present value and regression models of return on assets and cost of capital within a single framework; a panel specification of the models of return on assets and the weighted average cost of capital has been proposed together with an operationalized environmental risk index and a procedure for estimation and diagnostics; and the typology of sustainable financing strategies has been further developed by introducing distribution-based (tercile) criteria for selecting a strategy and linking each strategy to specific financing instruments.

The study has limitations. First, the article is methodological: the models are not estimated on empirical data, the numerical examples are hypothetical, and the expected signs of the parameters are hypotheses that require empirical testing. Second, when the methodology is applied, the results will depend on the sample: selection bias may arise if enterprises with complete environmental reporting differ systematically from other enterprises, and the external validity of the strategy thresholds is limited to the population from which they are derived. Third, the panel structure of the data requires enterprise and year effects; the period 2019 – 2023 contains strong common shocks - the COVID-19 pandemic, the energy crisis, and the full-scale war – that affect emissions, profitability, leverage, and the cost of capital simultaneously, and wartime reporting may be incomplete. Fourth, the relationships may be endogenous: profitable enterprises can afford more abatement, and financing conditions can influence emissions, so a causal interpretation requires lagged variables, instrumental variables, or quasi-experimental designs. Fifth, multicollinearity is possible between emissions, the environmental risk index, and enterprise size. Sixth, the cost of equity of non-listed enterprises is not observable, so WACC is measured with uncertainty. Finally, the weights of the integral indicator and of the environmental risk index involve a degree of subjectivity, and the sensitivity of the results to them should be tested.

CONCLUSIONS

The study achieved its aim of developing a methodology for the economic assessment of the impact of environmental pollution on enterprises' financial indicators. The conclusions correspond to the objectives set:

1. An integral model was formalized that combines the environmental parameters, financial indicators, and sustainable development indicators of an enterprise into a single indicator of the impact of pollution on its financial condition. The model makes it possible to compare enterprises with different environmental profiles and to monitor their financial vulnerability to environmental factors.
2. Second, the net present value model was modified by deducting environmental costs from cash flows and adding an environmental risk premium to the discount rate; to avoid double counting, expected environmental costs are included in cash flows, and only the residual systematic risk is included in the discount rate. The illustrative calculation showed that ignoring these factors can overstate the value of an investment project by UAH 10.49 million and turn a seemingly profitable project into a value-destroying one; therefore, the modified model should be used as a criterion for selecting investment projects.
3. Third, econometric models of return on assets and the weighted average cost of capital with environmental variables were specified for enterprise-year panel data; the environmental risk index was operationalized, and a procedure for their estimation was proposed, including enterprise and year effects, cluster-robust standard errors, and diagnostic tests. The expected signs of the parameters – negative for emissions in the profitability model and positive for emissions and environmental risk in the cost of capital model – are hypotheses for empirical testing.
4. A conceptual approach to forming sustainable financing strategies was developed as a closed cycle of diagnostic, strategic, investment, financial-managerial and communication components, and a typology of four strategies - environmental transformation, gradual ecologization, environmental improvement and environmental leadership - was proposed together with criteria for their selection based on the terciles of the environmental load coefficient and of the expected ROA loss.
5. Sector-specific recommendations were formulated: environmental insurance, reserve funds and «green» bonds for chemical and metallurgical enterprises; renewable energy, energy management and carbon financing for energy enterprises; ecodesign, product life cycle management and leasing for mechanical engineering; and certification, closed production cycles and microfinancing for the food industry.

Future research should test the proposed models empirically on panel data of enterprises, extend the regression models with energy consumption, waste volumes and industry effects, broaden the tools for assessing the impact of ESG factors on enterprises' financial strategies, and develop industry-specific methodologies for such assessment.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

FUNDING

The Authors received no funding for this research.

CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

REFERENCES

1. Alda, M. (2021). The environmental, social, and governance (ESG) dimension of firms in which social responsible investment (SRI) and conventional pension funds invest: The mainstream SRI and the ESG inclusion. *Journal of Cleaner Production, 298*, Article 126812. https://doi.org/10.1016/j.jclepro.2021.126812
2. Al-Tuwaijri, S. A., Christensen, T. E., & Hughes, K. E., II. (2004). The relations among environmental disclosure, environmental performance, and economic performance: A simultaneous equations approach. *Accounting, Organizations and Society, 29*(5–6), 447–471. https://doi.org/10.1016/S0361-3682(03)00032-1
3. Andrusiv, U., Stoliarenko, O., Kupalova, H., Honcharenko, N., Marynchak, L., & Chuchuk, Y. (2026). The impact of ESG factors on investment strategy formation and securities trading in the context of sustainable finance for Ukrainian enterprises. *Financial and Credit Activity Problems of Theory and Practice, 1*(66), 152–164. https://doi.org/10.55643/fcaptp.1.66.2026.4954
4. Andrusiv, U., Zelinska, H., Kupalova, H., Bezuhla, L., & Bieloborodova, M. (2024). The influence of the ecological situation in Ukraine on the life expectancy and health of the population. *Ekológia (Bratislava), 43*(2), 219–226. https://doi.org/10.2478/eko-2024-0023
5. Anquetin, T., Coqueret, G., Tavin, B., & Welgryn, L. (2022). Scopes of carbon emissions and their impact on green portfolios. *Economic Modelling, 115*, Article 105951. https://doi.org/10.1016/j.econmod.2022.105951
6. Avetisyan, E., & Hockerts, K. (2017). The consolidation of the ESG rating industry as an enactment of institutional retrogression. *Business Strategy and the Environment, 26*(3), 316–330. https://doi.org/10.1002/bse.1919
7. Bauer, R., & Smeets, P. (2015). Social identification and investment decisions. *Journal of Economic Behavior & Organization, 117*, 121–134. https://doi.org/10.1016/j.jebo.2015.06.006
8. Berry, T. C., & Junkus, J. C. (2013). Socially responsible investing: An investor perspective. *Journal of Business Ethics, 112*(4), 707–720. https://doi.org/10.1007/s10551-012-1567-0
9. Bertolotti, A. (2020). Effectively managing risks in an ESG portfolio. *Journal of Risk Management in Financial Institutions, 13*(3), 202–211. https://doi.org/10.69554/TQVN4497
10. BlackRock. (2023). *Global perspectives on investing in the low-carbon transition*. https://www.blackrock.com/institutions/en-au/literature/brochure/global-transition-investing-survey.pdf
11. Busch, T., & Lewandowski, S. (2018). Corporate carbon and financial performance: A meta-analysis. *Journal of Industrial Ecology, 22*(4), 745–759. https://doi.org/10.1111/jiec.12591
12. Chava, S. (2014). Environmental externalities and cost of capital. *Management Science, 60*(9), 2223–2247. https://doi.org/10.1287/mnsc.2013.1863
13. Chen, L., Zhang, L., Huang, J., Xiao, H., & Zhou, Z. (2021). Social responsibility portfolio optimization incorporating ESG criteria. *Journal of Management Science and Engineering, 6*(1), 75–85. https://doi.org/10.1016/j.jmse.2021.02.005
14. Chygryn, O., Pimonenko, T., Luylyov, O., & Goncharova, A. (2018). Green bonds like the incentive instrument for cleaner production at the government and corporate levels: Experience from EU to Ukraine. *Journal of Environmental Management and Tourism, 9*(7), 1443–1456. https://doi.org/10.14505//jemt.v9.7(31).09
15. Coase, R. H. (1960). The problem of social cost. *The Journal of Law and Economics, 3*, 1–44. https://doi.org/10.1086/466560
16. D'Amato, V., D'Ecclesia, R., & Levantesi, S. (2021). Fundamental ratios as predictors of ESG scores: A machine learning approach. *Decisions in Economics and Finance, 44*(2), 1087–1110. https://doi.org/10.1007/s10203-021-00364-5

17. De Spiegeleer, J., Höcht, S., Jakubowski, D., Reyners, S., & Schoutens, W. (2023). ESG: A new dimension in portfolio allocation. *Journal of Sustainable Finance & Investment, 13*(2), 827–867. https://doi.org/10.1080/20430795.2021.1923336

18. Derwall, J., Koedijk, K., & Ter Horst, J. (2011). A tale of values-driven and profit-seeking social investors. *Journal of Banking & Finance, 35*(8), 2137–2147. https://doi.org/10.1016/j.jbankfin.2011.01.009

19. Dimson, E., Karakaş, O., & Li, X. (2015). Active ownership. *The Review of Financial Studies, 28*(12), 3225–3268. https://doi.org/10.1093/rfs/hhv044

20. Eccles, R. G., Ioannou, I., & Serafeim, G. (2014). The impact of corporate sustainability on organizational processes and performance. *Management Science, 60*(11), 2835–2857. https://doi.org/10.1287/mnsc.2014.1984

21. Elamer, A. A., & Boulhaga, M. (2024). ESG controversies and corporate performance: The moderating effect of governance mechanisms and ESG practices. *Corporate Social Responsibility and Environmental Management, 31*(4), 3312–3327. https://doi.org/10.1002/csr.2749

22. Fan, L. W., Pan, S. J., Liu, G. Q., & Zhou, P. (2017). Does energy efficiency affect financial performance? Evidence from Chinese energy-intensive firms. *Journal of Cleaner Production, 151*, 53–59. https://doi.org/10.1016/j.jclepro.2017.03.041

23. Ferro, A., Marazzina, D., & Stocco, D. (2025). Uncovering ESG ratings: The (im)balance of aspirational and performance features. *Corporate Social Responsibility and Environmental Management, 32*(5), 5895–5917. https://doi.org/10.1002/csr.70007

24. Fisher, I. (1930). *The theory of interest*. Macmillan.

25. Freeman, R. E. (1984). *Strategic management: A stakeholder approach*. Pitman.

26. Gardiner, J., & Freke, T. (2024). *Green bonds reached new heights in 2023*. Bloomberg Professional Services. https://www.bloomberg.com/professional/insights/trading/green-bonds-reached-new-heights-in-2023/

27. Irtyshcheva, I., Popadynets, N., Sytnyk, Y., Andrusiv, U., Khromyak, Y., Kramarenko, I., Boiko, Y., & Sakharnatskyi, V. (2023). Management of the environmental potential of freshwater resources in the conditions of sustainable development. *Ecological Engineering & Environmental Technology, 24*(4), 229–235. https://doi.org/10.12912/27197050/162910

28. Ismail, M. N., Kallow, S. M., Gati, K. H., Al-Bayati, H. N. A., & Butsenko, Y. (2024). Quantitative approaches in decision theory for enhancing risk assessment strategies. *Journal of Ecohumanism, 3*(5), 308–321. https://doi.org/10.62754/joe.v3i5.3908

29. Jin, I. (2022). Systematic ESG risk and decision criteria for optimal portfolio selection. *The Journal of Portfolio Management, 48*(10), 206–225. https://doi.org/10.3905/jpm.2022.1.418

30. Kapil, S., & Rawal, V. (2023). Sustainable investment and environmental, social, and governance investing: A bibliometric and systematic literature review. *Business Ethics, the Environment & Responsibility, 32*(4), 1429–1451. https://doi.org/10.1111/beer.12588

31. King, A., & Lenox, M. (2002). Exploring the locus of profitable pollution reduction. *Management Science, 48*(2), 289–299. https://doi.org/10.1287/mnsc.48.2.289.258

32. Konar, S., & Cohen, M. A. (2001). Does the market value environmental performance? *The Review of Economics and Statistics, 83*(2), 281–289. https://doi.org/10.1162/00346530151143815

33. Kupalova, H., Honcharenko, N., Andrusiv, U., Oleshko, E., & Demchenko, K. (2025). Ecological modernisation of production for innovative development of industrial enterprises. *Financial and Credit Activity Problems of Theory and Practice, 1*(60), 512–521. https://doi.org/10.55643/fcaptp.1.60.2025.4606

34. Labenko, O., Lymar, V., Faichuk, O., Dolzhenko, I., Hutsol, T., Belei, S., Parafiniuk, S., Kwasniewski, D., Tabor, S., & Kiurcheva, L. (2024). Assessment of the efficiency of the financial mechanism of environmental management. *Production Engineering Archives, 30*(3), 314–325. https://doi.org/10.30657/pea.2024.30.31

35. Landrigan, P. J., Fuller, R., Acosta, N. J. R., Adeyi, O., Arnold, R., Basu, N., Baldé, A. B., Bertollini, R., Bose-O'Reilly, S., Boufford, J. I., Breysse, P. N., Chiles, T., Mahidol, C., Coll-Seck, A. M., Cropper, M. L., Fobil, J., Fuster, V., Greenstone, M., Haines, A., … Zhong, M. (2018). The Lancet Commission on pollution and health. *The Lancet, 391*(10119), 462–512. https://doi.org/10.1016/S0140-6736(17)32345-0

36. Modigliani, F., & Miller, M. H. (1958). The cost of capital, corporation finance and the theory of investment. *The American Economic Review, 48*(3), 261–297. https://www.jstor.org/stable/1809766

37. Ouchen, A. (2022). Is the ESG portfolio less turbulent than a market benchmark portfolio? *Risk Management, 24*(1), 1–33. https://doi.org/10.1057/s41283-021-00077-4

38. Pearce, D. W., & Turner, R. K. (1990). *Economics of natural resources and the environment*. Harvester Wheatsheaf.

39. Pedersen, L. H., Fitzgibbons, S., & Pomorski, L. (2021). Responsible investing: The ESG-efficient frontier. *Journal of Financial Economics, 142*(2), 572–597. https://doi.org/10.1016/j.jfineco.2020.11.001

40. Pigou, A. C. (1920). *The economics of welfare*. Macmillan.

41. Pimonenko, T., Chyhryn, O., & Liulov, O. (2018). Green entrepreneurship as an integral part of the national economy convergence. In *National security & innovation activities: Methodology, policy and practice* (pp. 358–366). National Academy of Security Service of Ukraine.

42. Pimonenko, T., & Lushyk, K. (2017). Green investing: EU experience for Ukraine. *Bulletin of Sumy State University. Economy Series*, (3), 61–67.

43. Porter, M. E., & van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives, 9*(4), 97–118. https://doi.org/10.1257/jep.9.4.97

44. Samaricheva, T., Samarichev, D., & Prokopov, V. (2024). «Green» taxation of enterprises as a key financial instrument of eco-innovation in Ukraine. *Financial and Credit Systems: Prospects for Development, 4*(15), 53–66. https://doi.org/10.26565/2786-4995-2024-4-05

45. Scholtens, B. (2006). Finance as a driver of corporate social responsibility. *Journal of Business Ethics, 68*(1), 19–33. https://doi.org/10.1007/s10551-006-9037-1

46. Scholtens, B. (2017). Why finance should care about ecology. *Trends in Ecology & Evolution, 32*(7), 500–505. https://doi.org/10.1016/j.tree.2017.03.013

47. Sharfman, M. P., & Fernando, C. S. (2008). Environmental risk management and the cost of capital. *Strategic Management Journal, 29*(6), 569–592. https://doi.org/10.1002/smj.678

48. Stanescu, S. G., Cucui, I., Ionescu, C. A., Paschia, L., Coman, M. D., Nicolau, N. L. G., Uzlau, M. C., & Lixandru, M. L. (2021). Conceptual model for integrating environmental impact in managerial accounting information systems. *International Journal of Environmental Research and Public Health, 18*(4), Article 1791. https://doi.org/10.3390/ijerph18041791

49. Useche, A. J., Martínez-Ferrero, J., & Alayón-Gonzales, J. L. (2024). Socially responsible portfolios, environmental, social, corporate governance (ESG) efficient frontiers, and psychic dividends. *Corporate Social Responsibility and Environmental Management, 31*(2), 1323–1339. https://doi.org/10.1002/csr.2635

50. Vasilyeva, T., Samusevych, Y., Babenko, V., Bestuzheva, S., Bondarenko, S., & Nesterenko, I. (2023). Environmental taxation: Role in promotion of the pro-environmental behaviour. *WSEAS Transactions on Business and Economics, 20*, 410–427. https://doi.org/10.37394/23207.2023.20.38

51. World Bank. (2025). *Accelerating access to clean air for a livable planet*. https://www.worldbank.org/en/publication/accelerating-access-to-clean-air-for-a-livable-planet

52. Zelinska, H., Andrusiv, U., Daliak, N., Dovgal, O., & Lagodiienko, V. (2021). Sustainable development: Trends in Ukraine and the world. *Journal of Environmental Management and Tourism, 12*(5), 1179–1187. https://doi.org/10.14505//jemt.v12.5(53).03

Андрусів У., Купалова Г., Гончаренко Н., Спасів Н., Попадинець Н., Кнейслер О.

ЕКОНОМІЧНА ОЦІНКА ВПЛИВУ ЗАБРУДНЕННЯ НА ФОРМУВАННЯ СТРАТЕГІЙ СТАЛОГО ФІНАНСУВАННЯ ПІДПРИЄМСТВ

Перехід до сталого розвитку вимагає від підприємств урахування фінансових наслідків забруднення довкілля, проте надійних інструментів їх кількісного оцінювання досі бракує. Метою дослідження є розроблення методичного підходу до економічної оцінки впливу забруднення довкілля на фінансові показники підприємств і обґрунтування на цій основі стратегій сталого фінансування. Підхід поєднує інтегральний показник впливу забруднення на фінансовий стан підприємства; модель чистої приведеної вартості, скориговану на екологічні витрати й премію за екологічний ризик; регресійні моделі рентабельності активів (ROA) та середньозваженої вартості капіталу (WACC), що містять екологічні змінні; а також індекс екологічного ризику та коефіцієнт екологічного навантаження з чіткими правилами розрахунку. Стаття має методичний характер: моделі специфіковано для застосування до панельних даних підприємств, запропоновано процедуру їх оцінювання та діагностики, а застосування продемонстровано на умовних ілюстративних прикладах, а не на емпіричних оцінках. Ілюстративний розрахунок показує, що ігнорування екологічних витрат і ризиків може перетворити проєкт із додатною чистою приведеною вартістю на такий, що знищує вартість. На цій основі запропоновано концептуальний підхід до формування стратегій сталого фінансування, що охоплює діагностичну, стратегічну, інвестиційну, фінансово-управлінську та комунікаційну складові, а також типологію з чотирьох стратегій: екологічної трансформації, поступової екологізації, екологічного вдосконалення та екологічного лідерства з критеріями вибору між ними на основі терцилів розподілу. Сформульовано галузеві рекомендації щодо інструментів фінансування. Отримані результати створюють методичну основу для інтеграції екологічних параметрів у фінансові стратегії підприємств і оцінювання інвестиційних проєктів.

Ключові слова: забруднення довкілля, стале фінансування, фінансова стратегія, рентабельність активів, середньозважена вартість капіталу, екологічний ризик, чиста приведена вартість, ESG, зелені фінанси, підприємство

JEL Класифікація: G31, G32, Q51, Q56, M14

DOI: 10.55643/fcaptp.5.70.2026.5342