sciendo

Management Theory and Studies for Rural Business and Infrastructure Development
eISSN 2345-0355. 2023. Vol. 46. No. 2: 152-165
Article DOI: https://doi.org/10.15544/mts.2023.16

FINANCIAL MANAGEMENT OF INNOVATIVE ECO-ENTREPRENEURSHIP

Olena Purdenko[1], Kostyantyn Artyushok[2], Nataliia Riazanova[3], Ihor Babaiev[4], Anna Kononenko[5], Tetyana Lepeyko[6], Mykola Zos-Kior[7*]

[1] *Assoc. Prof., State University of Traid and Economic, Kyiv, Ukraine, E-mail address: o.purdenko@knute.edu.ua*

[2] *Assoc. Prof., Academician Stepan Demianchuk International University of Economics and Humanities, Rivne, Ukraine, E-mail address: akostya@ukr.net*

[3] *Prof., Luhansk Taras Shevchenko National University, Poltava, Ukraine, E-mail address: natalirozez@gmail.com*

[4] *PhD student, Poltava State Agrarian University, Poltava, Ukraine, E-mail address: hardboj@gmail.com*

[5] *Assoc. Prof., Kyiv National University of Technologies and Design, Kyiv, Ukraine, E-mail address: annuta30@gmail.com*

[6] *Prof. Simon Kuznets Kharkiv National University of Economics, Kharkiv, Ukraine, E-mail address: lepeyko.tetyana@gmail.com*

[7] *Prof. Poltava State Agrarian University, Poltava, Ukraine, E-mail address: zoskior@gmail.com*

Received 17 06 2023; Accepted 20 06 2023

Abstract
The article focuses on the need to stimulate resource-saving and innovative technologies in production entrepreneurship to support environmental security. It is noted that the ecologisation of production will contribute to the reduction of energy intensity of the gross domestic product. The high level of energy intensity of Ukrainian industry was determined and the necessity of transition to alternative fuels was noted. In the scientific world, there is no effective methodology for the estimation of financial management of innovative ecological entrepreneurship. On this basis, our own methodology for such an assessment is offered. The system of indicators for the calculation of multifactor production function of the influence of measures of financial and innovative management on the ecologisation of business and level of power intensity in the GDP of Ukraine was defined. Forecasting of capital investments and current environmental protection costs by type of environmental protection measures was carried out. The insufficient level of investment and innovation support of entrepreneurship in Ukraine to ensure its environmental friendliness and reduction of energy intensity was noted. The purpose of the article is to assess the effectiveness of investment and innovation measures and their impact on the development of environmental entrepreneurship in the conditions of a rapidly changing external environment.

Keywords: *energy intensity of gross domestic product, management, innovations, entrepreneurship, ecology, resource conservation, environmental protection measures, investment, security, climate, finance.*

JEL Codes*: G32, H32, O32***.**

Introduction

Greening of production and implementation of resource-saving technologies is at the forefront of any country's policy. Financing for the greening of production and investing in resource-saving projects should be systematic. It is also important to correctly assess the current state of management regarding the financial support of ecological entrepreneurship with innovative technologies or measures. The problems we study are especially important in the context of the fact that the

Ukrainian industry is resource-intensive with an excessively high level of energy intensity. That is why there is a need to reduce the energy intensity of GDP and invest in alternative energy sources in order to promote environmental security. This will contribute to the goals of green growth and conservation of natural assets. The object of the study is to evaluate the financial management of innovative eco-entrepreneurship.

Literature review

The scholar (Khodakivska, O., 2014) examined the economic and social prerequisites for greening production in agriculture and reducing the energy intensity of the industry. Her article proposes a comprehensive solution to environmental problems in the agricultural sector at the micro and macro levels. The author rightly pointed out that modern society requires the implementation of innovative technological solutions to increase food production in the context of limited resources. In the study (Mukoviz, V. et al., 2022) scholars focus on the need to improve the quality of finance and accounting of agricultural enterprises, which is particularly important for reducing transaction costs and energy intensity of production. Many scientists (Mazur, N. et al., 2021; Sukhno, V. et al., 2022; Gryshchenko, I. et al., 2021; Khodakivska, O. et al., 2022; Aranchiy, V. et al., 2022) have proposed innovative mathematical modelling tools and ways of predicting events in the external environment that might affect business entities. Moreover, the logic of such modelling will be useful for our study. The research paper (Dey, A. et al., 2019) pointed out that innovation contributes to poverty alleviation as well as ensures increased greening of production. The findings (Ahmad, M. et al., 2021) regarding overcoming environmental challenges in G7 countries are interesting for our study. This study recommends G7 countries to be more united and plan together for financial projects related to environmental innovation. This would help economic growth by boosting production while conserving resources and consuming wisely. The relationship between ecological innovation and finance has been investigated in depth by several authors (Przychodzen, J. et al., 2015). In particular, the authors pointed out that four types of eco-innovations influence the financial efficiency of Polish and Hungarian companies. The authors rightly pointed out that eco-innovators have a greater chance of maximising profits and overcoming risks and challenges of the external environment. Important findings for our study are that innovation is important in accelerating the commercialisation of (clean) technologies (Polzin, F. et al., 2016). The authors prove that the problems of implementing environmental innovations can be overcome through effective financial management and institutional reforms. The research article (Lee, K. et al., 2015) correctly observes that there is a close relationship between corporate environmental and financial performance. However, this relationship has not been fully explored. Thus, we can witness the considerable attention of scholars to the issue of financial management of innovative environmental entrepreneurship, but the issues of effective methodology for calculating the dependence of financial management on the level of implementation of environmental innovation remain unresolved. The above make our research relevant and requires a deeper study of the issues under consideration.

Methodical approach

We propose to evaluate the effectiveness of financial management of innovative environmental entrepreneurship using stochastic modelling, described by a set of statistical quantities, between which there is a stochastic relationship. The analysis of a stochastic relationship is advisable to carry out with the use of correlation and regression analysis, where it is possible to build an economic and mathematical model of the regression equation that will show the dependence of the outcome indicator on the

sciendo
Management Theory and Studies for Rural Business and Infrastructure Development
eISSN 2345-0355. 2023. Vol. 46. No. 2: 152-165
Article DOI: https://doi.org/10.15544/mts.2023.16

factors involved in our study, which characterise the effectiveness of financial management of the innovative environmental enterprise. Such dependence can be described by a linear production function of multifactor type:

$$F = f_0 + f_1X_1 + f_2X_2 + \ldots + f_nX_n. \quad (1)$$

Based on a linear production function of multifactor type, we will investigate the impact of financial and innovation management measures on the greening of entrepreneurship and the energy intensity of Ukraine's GDP over twelve years. The main influencing factors on the energy intensity of Ukraine's GDP are:

capital investments in environmental protection by type of environmental protection measures, thousand UAH;

Current environmental protection expenditures by type of environmental protection measures, thousand UAH;

the number of innovative processes implemented aimed at greening entrepreneurship (units);

number of employees involved in research and development in the area of green business (persons).

For in-depth analysis and assessment of the effectiveness of multivariate regression and detailing of economic processes, the factor of capital investment in environmental protection and the factor of current environmental protection costs by type of environmental protection measures were selected, namely:

atmospheric air protection and climate change problem, thousand UAH;

treatment of return water, thousand UAH;

waste management, thousand UAH;

protection and rehabilitation of soil, groundwater and surface water, thousand UAH;

other activities, thousand UAH.

Data processing, calculations and efficiency forecasting are done using Microsoft Excel spreadsheets and built-in statistical and mathematical functions and arrays. We denote the factors:

X_0 is a fictitious factor, always designated "1" in the calculations and indicating the total number of years, in this study twelve years;

X_1 capital investments for environmental protection by types of environmental protection measures, thousand UAH;

X_{11} atmospheric air protection and climate change issues, thousand UAH;

X_{12} treatment of return water, thousand UAH;

X_{13} waste management, thousand UAH;

X_{14} protection and rehabilitation of soil, groundwater and surface water, thousand UAH;

X_{15} other activities, thousand UAH;

X_2 current costs of environmental protection by types of environmental protection measures, thousand UAH;

X_{21} atmospheric air protection and climate change problem, thousand UAH;

X_{22} - treatment of return water, thousand UAH;

X_{23} waste management, thousand UAH;

X_{24} protection and rehabilitation of soil, groundwater and surface water, thousand UAH;

X_{25} other activities, thousand UAH;

X_3 number of implemented innovative processes aimed at greening entrepreneurship (units);

X_4 number of employees involved in research and development in the field of business greening (people).

The resulting indicator in this production regression is Y, the energy intensity of GDP by PPP 2017, billion UAH.

At the initial stage, it is necessary to determine the input information required to assess the financial management of innovative eco-entrepreneurship. Using the data from the official statistical resource of Ukraine, the information data is grouped in Table 01.

Table 1. Input data for calculation of a multifactor production function for the impact of financial and innovation management measures on the greening of business and the energy intensity of Ukrainian GDP, 2010-2021 (grouped by factor groups)

Group 1 indicators						
Years	Fictitious factor, X_0	**Capital investments in environmental protection by type of environmental protection measures, thousand UAH, X_1**				
		Air protection and climate change issue, UAH thousand., X_{11}	Treatment of return water, UAH thousand., X_{12}	Waste management, UAH thousand., X_{13}	Protection and rehabilitation of soil, groundwater and surface water, UAH thousand., X_{14}	Other activities, thousand UAH., X_{15}
2010	1	1139946,70	734663,40	475584,30	319922,00	91355,70
2011	1	2535632,60	721325,50	1183880,20	639123,10	1371073,20
2012	1	2462675,30	846955,40	730544,40	540516,80	2008644,60
2013	1	2411935,10	834114,80	713856,30	324980,10	1753896,70
2014	1	1915129,70	1122149,30	783965,40	359925,60	3778683,90
2015	1	1422946,60	848881,20	737498,90	388259,20	4278011,10
2016	1	2502805,80	1160029,10	2208676,60	419988,90	7098976,90
2017	1	2608027,40	1276530,20	2470969,50	1284502,00	3385506,10
2018	1	3505920,60	1692640,70	1182045,80	1444291,60	2249380,60
2019	1	4276767,60	1753869,10	5754260,90	1721924,90	2748849,30
2020	1	5595319,40	1578201,40	2899793,40	2554224,50	612111,10
2021	1	6714383,28	1893841,68	3479752,08	3065069,40	734533,32
Group 2 indicators						
Years	**Current environmental protection expenditures by type of environmental protection measures, UAH thousand., X_2**					
	Air protection and climate change issues, UAH thousand., X_{21}	Treatment of return water, UAH thousand., X_{22}	Waste management, UAH thousand., X_{23}	Protection and rehabilitation of soil, groundwater and surface water, UAH thousand., X_{24}	Other activities, thousand UAH., X_{25}	
2010	1314797,00	5035453,30	2599623,30	476253,50	940438,40	
2011	1475396,90	5388363,20	3865909,70	592730,40	717039,30	
2012	1341527,80	6195109,80	4756182,10	743467,10	888367,50	
2013	1415795,50	6175917,30	4844304,80	923236,00	979806,80	
2014	1238636,70	5611561,40	5416975,60	964737,00	733815,30	
2015	1519827,80	6644284,70	6801931,20	1152701,90	796789,60	
2016	1760613,40	7800088,30	6719577,70	1197194,30	1620751,10	
2017	2104274,30	8065252,40	7508213,70	983781,80	1804901,10	
2018	2897672,00	9623474,40	8830203,50	1288375,00	1678266,10	
2019	2963889,10	10872744,20	10227144,30	1583926,50	1832486,20	
2020	2375792,80	10746809,80	11197148,10	1577030,80	2195770,40	
2021	2613372,08	11821490,78	12316862,91	1734733,88	2415347,44	
Group 3 indicators						

sciendo

Management Theory and Studies for Rural Business and Infrastructure Development
eISSN 2345-0355. 2023. Vol. 46. No. 2: 152-165
Article DOI: https://doi.org/10.15544/mts.2023.16

Years	Number of implemented innovative processes aimed at greening entrepreneurship (units), X_3	Number of employees involved in research and development in the field of business greening (persons), X_4	Energy intensity of GDP by PPP 2017, billion UAH, Y
2010	2503	20276	4306,19
2011	2908	19481	4541,31
2012	3602	18260	4563,89
2013	4058	17265	4585,13
2014	4917	15125	6344,50
2015	5023	13612	10515,96
2016	4879	10879	12575,71
2017	4598	10475	13417,04
2018	4639	9792	14184,80
2019	4879	8807	13912,47
2020	5029	8762	13965,28
2021	5307	8968	13877,70

**Source: Indicators systematised by the authors using the official Ukrainian statistical resource https://www.ukrstat.gov.ua/*

In order to achieve the goal of the article, we also used methods of abstraction, induction, deduction, analysis, synthesis, and mathematical modeling.

Results

To arrange the indicators shown in Table 1 and form a correlation matrix to study the impact of 0financial and innovation management measures on the greening of entrepreneurship and the level of energy intensity of Ukraine's GDP, we use the built-in statistical functions of Microsoft Excel spreadsheets: SUM, AVERAGE, STDEV and STANDARDIZE for the factors:

capital investments in environmental protection by type of environmental protection measures, thousand UAH;

current environmental protection expenditures by type of environmental protection measures, thousand UAH;

the number of innovative processes implemented aimed at greening entrepreneurship (units);

number of employees involved in research and development in the area of green business (persons).

And also for the indicator:

energy intensity of GDP by PPP 2017, UAH billion

The calculations are presented in Table 2.

Table 2. Normalisation of initial factor and indicator data for correlation matrix processing, 2010-2021

Years	Capital investments in environmental protection by type of environmental protection measures, thousand UAH., Xn_1	Current environmental protection expenditures by type of environmental protection measures, UAH thousand., Xn_2	Number of implemented innovative processes aimed at greening business (units), Xn_3	Number of employees involved in research and development in the field of greening business (persons), Xn_4	STANDARDIZE				
					Y*	Xn_1	Xn_2	Xn_3	Xn_4

2010	-1,73	-1,35	-2,15	1,60	-1,28	-1,73	-1,35	-2,15	1,60
2011	-0,82	-1,10	-1,68	1,42	-1,22	-0,82	-1,10	-1,68	1,42
2012	-0,78	-0,82	-0,88	1,13	-1,22	-0,78	-0,82	-0,88	1,13
2013	-0,92	-0,75	-0,35	0,89	-1,21	-0,92	-0,75	-0,35	0,89
2014	-0,45	-0,81	0,64	0,39	-0,80	-0,45	-0,81	0,64	0,39
2015	-0,52	-0,36	0,76	0,03	0,18	-0,52	-0,36	0,76	0,03
2016	0,89	-0,03	0,60	-0,61	0,67	0,89	-0,03	0,60	-0,61
2017	0,31	0,17	0,27	-0,71	0,87	0,31	0,17	0,27	-0,71
2018	0,07	0,75	0,32	-0,87	1,05	0,07	0,75	0,32	-0,87
2019	1,59	1,23	0,60	-1,10	0,99	1,59	1,23	0,60	-1,10
2020	0,85	1,32	0,77	-1,11	1,00	0,85	1,32	0,77	-1,11
2021	1,50	1,75	1,09	-1,06	0,98	1,50	1,75	1,09	-1,06

**Source: calculated by the authors.*

When looking at the calculations made, it should be noted that in order to process the statistical data, it is advisable to use the built-in statistical function of Microsoft Excel spreadsheets STANDARDIZE in order to streamline and optimise the calculation.

Next, when investigating the multifactor linear model of GDP energy intensity, we conduct multicollinearity checks using the Farrar-Glober method. Since $X_i^2{}_{calculated}(36,48) > X_i^2{}_{kp}(9,49)$, we can conclude that the overall multicollinearity of the factor matrix exists.

At the next stage of the study, we calculate pairwise correlation coefficients indicating the influence of individual factors on indicator Y, i.e. energy intensity of GDP. We estimate the closeness of the relationship if its absolute value is: less than 0.3- the relationship is weak; within 0.3-0.7- the relationship is medium; more than 0.7-dense; equal to the 1-functional relationship.

As noted earlier, the factor of capital investment in environmental protection and the factor of current environmental protection expenditure by type of environmental protection measure were chosen for in-depth multivariate regression analysis and detailing of economic processes, namely:

atmospheric air protection and climate change problem, thousand UAH;

treatment of return water, thousand UAH;

waste management, thousand UAH;

protection and rehabilitation of soil, groundwater and surface water, thousand UAH;

other activities, thousand UAH.

Therefore, the author`s own work is to analyse and investigate the impact of these economic factors by type of environmental protection measures on the resulting indicator of GDP energy intensity efficiency (Table 3).

sciendo

Management Theory and Studies for Rural Business and Infrastructure Development
eISSN 2345-0355. 2023. Vol. 46. No. 2: 152-165
Article DOI: https://doi.org/10.15544/mts.2023.16

Table 3. Study on the impact of capital investments and current expenditures on environmental protection by type of environmental protection measures on the energy intensity of GDP, 2010-2021

Factors influencing the energy intensity of GDP	Pairwise correlation coefficients of the impact of capital investment on environmental protection by type of environmental protection measures on GDP energy intensity	Correlation coefficient, r	Characteristics	Pairwise correlation coefficients of the impact of current expenditures on environmental protection by type of environmental protection measures on the energy intensity of GDP	Correlation coefficient, r	Characteristics
air protection and climate change issues, UAH thousand., X_{11}	r_{YX11}=	0,64	The relationship between the factor and the indicator is direct, medium	r_{YX21}=	0,86	The relationship between the factor and the indicator is direct and close
treatment of return water, thousand UAH., X_{12}	r_{YX12}=	0,86	The relationship between the factor and the indicator is direct and close	r_{YX22}=	0,88	The relationship between the factor and the indicator is direct and close
Waste management, UAH thousand., X_{13}	r_{YX13}=	0,69	The relationship between the factor and the indicator is direct, medium	r_{YX23}=	0,88	The relationship between the factor and the indicator is direct and close
Protection and rehabilitation of soil, groundwater and surface water, UAH thousand., X_{14}	r_{YX14}=	0,71	The relationship between the factor and the indicator is direct and close	r_{YX24}=	0,86	The relationship between the factor and the indicator is direct and close
Other activities, thousand UAH., X_{15}	r_{YX15}=	0,25	The relationship between the factor and the indicator is direct, weak	r_{YX25}=	0,86	The relationship between the factor and the indicator is direct and close

**Source: calculated by the authors.*

As can be seen from the calculations, the pairwise correlation coefficients of influence on the energy intensity of GDP are quite high and qualitative, only capital investments in other environmental measures have a weak influence on the result indicator.

Next, continuing the study of the impact of the main factors of the greening of entrepreneurship and business on the energy intensity of GDP, we calculate pairwise correlation coefficients for the dependence of the result indicator on each of the studied factors using different methodologies:

using normalised factor and indicator data;

using the built-in statistical function CORREL in Microsoft Excel spreadsheets;

using the Data tool→ Data analysis→ Microsoft Excel spreadsheet correlation (Table 4).

Table 4. Determining the pairwise correlation coefficients of the impact of the main factors of the greening of entrepreneurship and business on the energy intensity of GDP, 2010-2021

Factors of influence on the energy intensity of GDP	Symbols and notation	Pairwise correlation coefficients of the dependence of GDP energy intensity on the factors under study		
		using normalised data	using the built-in statistical function CORREL of Microsoft Excel spreadsheets	using the Data tool→ Data analysis→ Microsoft Excel spreadsheet correlation
Capital investments in environmental protection by type of environmental protection measures	r_{YX1}	0,86	0,86	0,86
Current environmental protection costs by type of environmental protection measures	r_{YX2}	0,89	0,89	0,89
Number of implemented innovative processes aimed at greening business	r_{YX3}	0,78	0,78	0,78
Number of employees involved in research and development in the field of business greening	r_{YX4}	-0,98	-0,98	-0,98

**Source: calculated by the authors.*

By characterising the pairwise correlation coefficients using different methods, it can be seen that each factor has a significant impact on the energy intensity of GDP:

capital investments in environmental protection by type of environmental protection measures, pairwise correlation coefficient 0.86, the relationship is close, a direct influence on the result indicator;

current environmental expenditures by type of environmental protection measures, pairwise correlation coefficient 0.89, correlation close, direct impact on the energy intensity of GDP;

the number of innovative processes implemented aimed at greening entrepreneurship, pairwise correlation coefficient 0.78, the relationship is close, a direct influence on the performance indicator;

the number of employees involved in performing research and development in green business, pairwise correlation coefficient -0.98, relationship close, inverse effect on the energy intensity of GDP.

Given the high and qualitative pairwise correlation coefficients, we further investigate and predict the energy intensity of GDP with the four factors without excluding any of the study. Next, we calculate and compare equation coefficients, coefficient of determination, Fisher's F-criterion, data standard error value and the number of observations, using the built-in statistical function LINEST of Microsoft Excel spreadsheets and Microsoft Excel spreadsheet data analysis add-in (Data → Data Analysis→ Regression) (Table 5).

sciendo

Management Theory and Studies for Rural Business and Infrastructure Development
eISSN 2345-0355. 2023. Vol. 46. No. 2: 152-165
Article DOI: https://doi.org/10.15544/mts.2023.16

Table 5. Results of data processing to determine the impact of the main greening factors of entrepreneurship and business on the energy intensity of GDP, 2010-2021

Using the built-in statistical function LINEST in Microsoft Excel spreadsheets								
The production function of energy intensity of GDP, Y	Regression parameters					Coefficient of determination R2	The calculated value of Fisher's F criterion, F calculated	Table value F of Fisher's test, F table
	a_0	a_1	a_2	a_3	a_4			
$\hat{Y}=38179,70-0,0001X_1-0,0001X_2-1,42\ X_3-1,45\ X_4$	38179,70	-0,0001	-0,0001	-1,42	-1,45	0,98	113,36	74,39
Using the Microsoft Excel Spreadsheet Data Analysis add-in								
Production function of energy intensity of GDP, Y	Regression parameters					Coefficient of determination R2	The calculated value of Fisher's F criterion, F calculated	Table value F of Fisher's test, F table
	a_0	a_1	a_2	a_3	a_4			
$\hat{Y}=38179,70-0,0001X_1-0,0001X_2-1,42\ X_3-1,45\ X_4$	38179,70	-0,0001	-0,0001	-1,42	-1,45	0,98	113,36	74,39

**Source: calculated by the authors.*

Thus, equation coefficients, coefficient of determination, Fisher's F-criterion, data standard error value and the number of observations of multifactor production regression of energy intensity of GDP using two data processing tools are obtained.

A multivariate production regression of the energy intensity of GDP is as follows:

$$Yr=38179,70-0,0001X_1-0,0001X_2-1,42\ X_3-1,45\ X_4$$

Let us look in more detail at the statistical coefficients and parameters of the multifactor production function of the energy intensity of GDP. Given that the parameters of the equation are calculated by the least squares method, we have a_0=38179,70; a_1=-0,0001; a_2=-0,0001; a_3=-1,42 and a_4=-1,45.

Consequently, as the value decreases:

- capital investment in environmental protection by types of environmental protection measures per 1,000 UAH, the energy intensity of GDP will decrease by 0.0001 billion UAH;
- current environmental protection expenditures by types of environmental protection measures per 1,000 UAH, the energy intensity of GDP will decrease by 0.0001 billion UAH;
- the number of innovative processes implemented aimed at greening entrepreneurship per unit, the energy intensity of GDP will decrease by 1.42 billion UAH;
- the number of employees involved in the implementation of research and development in the field of business greening per 1 person, the energy intensity of GDP will decrease by 1.45 billion UAH.

The production regression coefficients of the energy intensity of GDP are negative values and are based on statistical calculations.

The data processing results in an overall coefficient of determination of 0.98. The overall coefficient of determination indicates a close, direct relationship between the factors and the indicator, and that the variation of the energy

intensity of GDP by 97.70% is determined by the studied factors introduced into the correlation model. This means that the selected factors have a significant impact on the investigated indicator - energy intensity of GDP.

In order to determine the quality of the calculated model, an analysis of Fisher's F-criterion has been carried out. As a result, it was determined that the multifactor linear econometric model with reliability P=0.95 can be considered adequate to the experimental data and based on the adopted model it is possible to conduct economic analysis and forecasting of GDP energy intensity, as $F_{calculated}(113,36)>F_{table}(74,39)$.

At the end of this stage of the study, it is worth reiterating the alternative methods for studying economic processes, in this case, the energy intensity of GDP and the factors influencing this indicator, which can be used by scientists and economists for qualitative research, rationalisation and optimization.

Next, let us build a basic table of analysis of variance (ANOVA tables) to determine the variance and standardised residual error to estimate the production regression of the energy intensity of GDP (Table 6).

Table 6. Calculation of the ANOVA table in the study of the impact of the main factors of the greening of entrepreneurship and business on the energy intensity of GDP, 2010-2021

The source of variation	Degrees of freedom		Sum of squares		Dispersions (mean squares)	
Regressions	k_1 = m - 1	3	SSR =	210790935,86	MSR =	70263645,29
Residuals	k_2 = n- m	8	SSE=	4958595,22	MSE=	619824,40
The overall variable	n - 1	11	SST=	215749531,08	MST =	19613593,73

**Source: calculated by the authors.*

Using an ANOVA - table, we determine:

the variance of the GDP energy intensity regression is 70263645.29;

the unbiased estimate of the variance of the residuals is 619824.40;

the standardised residual error is 787.29;

the variance of the dependent variable (total variance) is 19613593.73.

Comparing the determined variance values, we conclude that they are equal to the determined values using the built-in statistical function LINEST of Microsoft Excel spreadsheets and the Data Analysis add-in of Microsoft Excel spreadsheets.

The production regression of the energy intensity of GDP and the factors affecting this indicator is well-fitted, as evidenced by the standardised residual error of 787.29, the smaller it is, the better the model.

A coefficient of determination without regard to the number of degrees of freedom, 0.98, has been pre-determined by various tools. Let us determine the adjusted coefficient of determination taking into account the number of degrees of freedom (Theil's formula) 0.97. In this case, the coefficient of determination without taking into account the number of degrees of freedom is more successful, 0.98. Multiple correlation coefficient, pre-determined by Data Analysis tool, R = 0.99. The multiple correlation coefficient is a measure of the linear relationship between the energy intensity of GDP (dependent variable Y) and the main greening factors of entrepreneurship and business (independent variables X_1, X_2, X_3, X_4). Since the multiple correlation coefficient approaches unity, this indicates a sufficiently strong and close relationship between the result indicator and the factors under study.

The next step is to analyse the elasticity coefficient, calculated for each of the factors. The elasticity coefficient shows by how much

sciendo
Management Theory and Studies for Rural Business and Infrastructure Development
eISSN 2345-0355. 2023. Vol. 46. No. 2: 152-165
Article DOI: https://doi.org/10.15544/mts.2023.16

the indicator, i.e. the energy intensity of GDP, would change if a factor were to change by 1%. Consequently, the partial elasticity coefficients are as follows:

E_1=-0,14;
E_2=-0,14;
E_3=-0,64;
E_4=-2,01.

That is, if the main greening factors of entrepreneurship and business decrease by 1%, the energy intensity of GDP will decrease by 0.14%, 0,14%, 0.64% and 2.01%.

The overall elasticity in our study is 2.92% and shows that if all the factors of greening business and entrepreneurship are changed simultaneously by 1%, the energy intensity of GDP will change by 2.92%.

The final stage is the forecasting of the factors under study, including the types of environmental protection measures, which are the author's contribution, the energy intensity of GDP and the graphical presentation of the results obtained.

The forecasting of capital investments and current environmental expenditures by type of environmental protection measures was carried out using the built-in statistical function TREND of Microsoft Excel spreadsheets, which is linear and best reflects the upward trend of the respective factors (Table 7).

Table 7. Forecasting capital investments and current environmental protection expenditures by type of environmental protection measures, 2024-2025

Factors of influence on the energy intensity of GDP	**The 2024 year**	**Deviations 2024 from 2021., ±**	**The 2025 year**	**Deviations 2025 from 2021 p., ±**
Capital investments in environmental protection by type of environmental protection measures, thousand UAH., X_1				
air protection and climate change issues, UAH thousand., X_{11}	6365630,34	-348752,94	6750885,97	36502,69
Wastewater treatment, UAH thousand., X_{12}	2152694,65	258852,97	2264156,75	370315,07
Waste management, UAH thousand., X_{13}	4635033,48	1155281,40	4958558,72	1478806,64
Protection and rehabilitation of soil, groundwater and surface water, UAH thousand., X_{14}	2993761,59	-71307,81	3217902,87	152833,47
Other activities, thousand UAH., X_{15}	737500,32	2967,00	742020,10	7486,78
Current environmental protection expenditures by type of environmental protection measures, UAH thousand., X_2				
air protection and climate change issues, UAH thousand., X_{11}	3225905,94	612533,86	3379722,37	766350,29
Wastewater treatment, UAH thousand., X_{12}	13222095,49	1400604,71	13856258,19	2034767,41
Waste management, UAH thousand., X_{13}	14142616,50	1825753,59	14972296,12	2655433,21
Protection and rehabilitation of soil, groundwater and surface water, UAH thousand., X_{14}	2008354,80	273620,92	2115041,96	380308,08
Other activities, thousand UAH., X_{15}	2681560,40	266212,96	2834255,94	418908,50

**Source: calculated by the authors.*

As can be seen from the forecast calculations, capital investments and current environmental protection costs by type of environmental protection measures for the next period are growing, which is logical and justified. However, capital investments for air protection and climate change problems, protection, and rehabilitation of soil, groundwater and surface water decrease slightly in the forecast year 2024 but increase again in 2025.

Next, we forecast capital investments and current expenditures on environmental protection by type of environmental protection measures in the total volume, the number of innovative processes implemented aimed at greening the business, the number of employees involved in research and development in the field of greening business and energy intensity of GDP. The influence factors on the energy intensity of GDP are still using the built-in TREND statistical function of Microsoft Excel spreadsheets. The resulting indicator is the energy intensity of GDP using multivariate production regression $Yr=38179,70-0,0001X_1-0,0001X_2-1,42 X_3-1,45 X_4$. (Table 8).

Table 8. Forecasting the main factors of greening entrepreneurship and business, and energy intensity of GDP, 2024-2025

Factors and performance indicator	**The 2024 year**	**Deviations 2024 from 2021., ±**	**The 2025 year**	**Deviations 2025 from 2021., ±**
Factors influencing the energy intensity of GDP				
Capital investments in environmental protection by type of environmental protection measures, UAH thousand, X1	18940039,52	3052459,76	20017796,42	4130216,66
Current environmental protection expenditures by type of environmental protection measures, UAH thousand., X_2	35280533,13	4378726,04	37157574,58	6255767,49
The number of implemented innovative processes aimed at greening entrepreneurship, (units),X_3	6165	858	6377	1070
Number of employees involved in research and development in the field of business greening (persons), X_4	8998	30	9440	472
Resulting indicator				
Energy intensity of GDP, billion UAH., Y	14263,49	385,79	14539,65	661,95

**Source: calculated by the authors.*

Thus, the conducted forecasting of the main factors of the greening of entrepreneurship and business, and the energy intensity of GDP shows that the main factors of influence on the energy intensity of GDP increase in comparison with 2021, which leads to an increase in the resulting indicator - the energy intensity of GDP.

Finalising the study and forecasting the impact of main greening factors on the energy intensity of GDP, 2010-2021, 2024-2025, we present a graphical multifactor production regression, where actual, theoretical and predicted values of the energy intensity of GDP are indicated (Figure 1).

Management Theory and Studies for Rural Business and Infrastructure Development
eISSN 2345-0355. 2023. Vol. 46. No. 2: 152-165
Article DOI: https://doi.org/10.15544/mts.2023.16

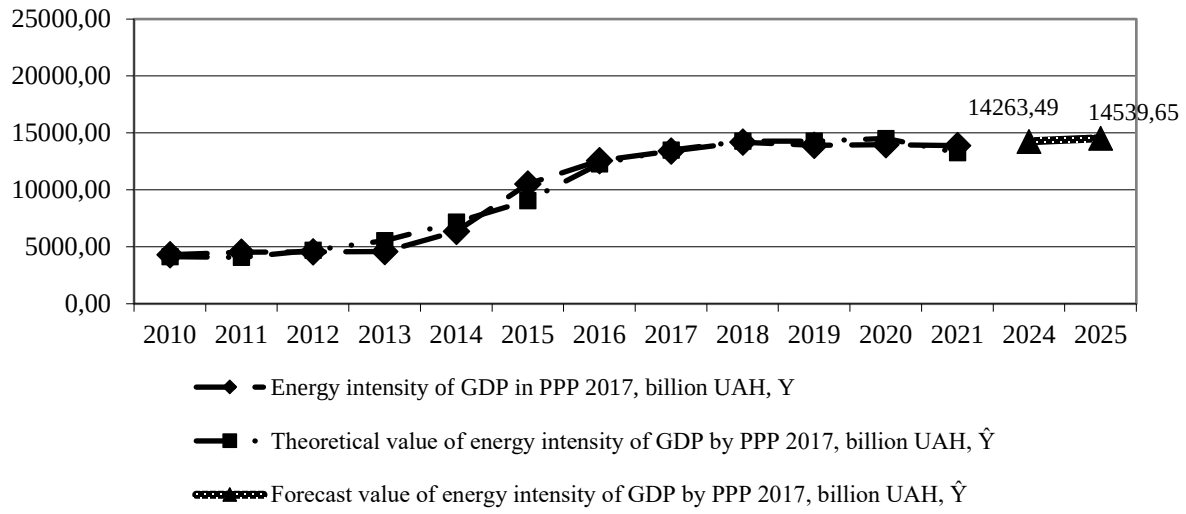

Figure 1. Actual, theoretical and predicted values of GDP energy intensity, 2010-2021, 2024-2025
**Source: calculated by the authors.*

Therefore, the correlation and regression analysis, construction and analysis of the economic and mathematical model of the regression equation and prediction of the main factors of ecologisation of entrepreneurship and business and energy intensity of GDP by different means and automation tools define the main directions of economic processes management on micro-, meso- and macrolevels.

Conclusions

The proposed methodology for assessing the financial management of innovative eco-entrepreneurship is simple enough to be applied in public administration and business. The modelling results have shown negative trends in the greening of business and an insufficient financial base to support resource-saving technologies. The existing level of capital investment in environmental protection, current costs for environmental protection measures, the number of implemented innovative processes aimed at greening entrepreneurship and the number of employees involved in research and development in the field of greening business are insufficient to reduce energy intensity. This indicates the technological backwardness of Ukraine's industry, the presence of a shadow sector in the economy, inefficient export-import operations and low institutional support for environmental safety. There is a need for a fundamental review of investment, innovation, human resources and institutional policies and the formation of regional entrepreneurial ecosystems in order to maintain green production.

References

Khodakivska, O. (2014). Socio-economic backgrounds of agricultural production ecolo gization. *Management theory and studies for rural business and infrastructure development*, *36*(3), 526-534.

Mukoviz, V., Leshchii, L., Khodakivska, O., Prokopova, O., Kuzub, M. (2022). Accounting for transactions costs of agricultural producers in the shadow economy. *Agricultural and Resource Economics: International Scientific E-Journal*, *8*(1868-2022-775), 67-85.

Mazur, N., Khrystenko, L., Pásztorová, J., Zos-Kior, M., Hnatenko, I., Puzyrova, P., Rubezhanska, V. (2021). Improvement of controlling in the financial management of enterprises. *TEM Journal-Technology, Education, Management, Informatics, 10*(4), 1605-1609. DOI: 10.18421/TEM104-15

Sukhno, V. V., Vashchenko, P. A., Saenko, A. M., Zhukorskyi, O. M., Tserenyuk, O. M., Kryhina, N. V. (2022). Association of Fut1 and Slc11a1 gene polymorphisms with productivity traits of Large White pigs. Regulatory Mechanisms in Biosystems, *13*(3), 225–230. DOI: 10.15421/022229

Gryshchenko, I., Ganushchak–Efimenko, L., Shcherbak, V., Nifatova O., Zos-Kior M., Hnatenko, I., Martynova, L., Martynov, A. (2021). Making Use of Competitive Advantages of a University Education Innovation Cluster in the Educational Services Market. *European Journal of Sustainable Development*, *10*(2), 336. DOI: 10.14207/ejsd. 2021.v10n2p336

Khodakivska, O., Kobets, S., Bachkir, I., Martynova, L., Klochan, V., Klochan, I., Hnatenko, I. (2022). Sustainable development of regions: Modeling the management of economic security of innovative entrepreneurship. *International Journal of Advanced and Applied Sciences*, *9*(3), 31-38. DOI: 10.21833/ijaas.2022.03.004

Aranchiy, V., Ganushchak-Efimenko, L., Khrystenko, L., Shkoda, M., Hnatenko, I., Fastovets, N. (2022). Modeling of integrated assessment of the effectiveness of management of the financial position of business entities. *Financial and Credit Activity Problems of Theory and Practice*, *1*(42), 259–270. DOI: 10.55643/fcaptp.1.42.2022.3526

Dey, A., Gupta, A. K., Singh, G. (2019). Innovation, investment and enterprise: Climate resilient entrepreneurial pathways for overcoming poverty. *Agricultural Systems*, *172*, 83-90. DOI: 10.1016/j.agsy.2018.07.013

Ahmad, M., Jiang, P., Murshed, M., Shehzad, K., Akram, R., Cui, L., Khan, Z. (2021). Modelling the dynamic linkages between eco-innovation, urbanization, economic growth and ecological footprints for G7 countries: does financial globalization matter? *Sustainable Cities and Society*, *70*, 102881. DOI: 10.1016/j.scs.2021.102881

Przychodzen, J., Przychodzen, W. (2015). Relationships between eco-innovation and financial performance–evidence from publicly traded companies in Poland and Hungary. *Journal of Cleaner Production*, *90*, 253-263. DOI: 10.1016/j.techfore.2015.10.001

Polzin, F., von Flotow, P., Klerkx, L. (2016). Addressing barriers to eco-innovation: Exploring the finance mobilization functions of institutional innovation intermediaries. *Technological Forecasting and Social Change. Technological Forecasting and Social Change*, *103*, 34-46.

Lee, K. H., Min, B. (2015). Green R&D for eco-innovation and its impact on carbon emissions and firm performance. *Journal of Cleaner Production*, *108*, 534-542. DOI: 10.1016/j.jclepro.2015.05.114