An intelligent method for the analysis of fiscal incentives for green investment*

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Abstract

The article substantiates the relevance of assessing the effectiveness of fiscal incentives for green investment in Ukraine in the context of martial law, post-war recovery, European integration processes, and the need to transition to a sustainable development model. It is determined that fiscal instruments, in particular environmental taxation, budget expenditures, tax and customs incentives, grant support, and subsidies, play an important role in creating the financial prerequisites for the ecological modernization of the economy. The purpose of the study is to develop an intelligent approach to assessing the effectiveness of fiscal incentives for green investment based on the use of fuzzy logic. The paper proposes a fuzzy model that makes it possible to formalize cause-and-effect relationships between fiscal, investment, and environmental indicators. The input variables of the model include the amount of environmental taxes paid, budget expenditures on environmental protection, enterprises' capital investments, enterprises' current expenditures on environmental protection activities, and the level of use of fiscal incentives for green investment. The output variable is the level of effectiveness of fiscal incentives for green investment, represented by the linguistic values of "small effectiveness", "moderate effectiveness", and "high effectiveness". The developed "if–then" rule base enables scenario analysis of the impact of individual factors on the effectiveness of state support for green investment. The proposed model makes it possible to combine quantitative statistical indicators and expert judgments, thereby increasing the validity of management decisions in the field of green fiscal policy. The practical value of the study lies in the possibility of using the proposed approach to assess the effectiveness of tax and budgetary incentives, determine priorities for financing environmental protection measures, improve mechanisms of state support for green investment, and form an analytical basis for the ecological modernization of Ukraine's economy.

Keywords

fuzzy logic, financial policy, fiscal stimulus, tax breaks, green investments, environmental safety, fuzzy set analysis, intelligent methods, sustainable development, analysis, audit [1]

1. Introduction

In the current conditions of martial law and the formation of strategic priorities for the post-war recovery of Ukraine, the search for effective mechanisms for financial support for the ecological modernization of the economy and the stimulation of green investments is of particular relevance. Green investments play an important role in the formation of an environmentally safe environment, improving the quality of life of the population, rational use of natural resources and ensuring long-term sustainability of socio-economic development. The strengthening of European integration processes, the need to implement the principles of sustainable development and the transformation of financial policy in accordance with modern global challenges determine the need

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to form adaptive fiscal instruments capable of combining fiscal incentives, investment mechanisms and environmental priorities. At the same time, traditional approaches to assessing the effectiveness of fiscal incentives do not always take into account the multifactorial nature of the relationships between environmental taxation, budget support, investment activity of business entities and the results of the green transition. The relevance of the study is determined by the need to develop an intellectual method for evaluating fiscal incentives for green investments as a tool for increasing the efficiency of the use of financial resources, ensuring the ecological transformation of the economy, and implementing the strategic priorities of Ukraine's European integration.

2. Literature review

Scientific interest in the issue of fiscal incentives for green investments has significantly increased in response to growing environmental challenges and the need to ensure the transition to a small-carbon economy. According to the results of a search in the Scopus scientometric database using the key phrases “fiscal incentives” and “green investments”, 136 scientific papers were identified, indicating considerable research interest in this topic [1]. Figure 1 shows the number of papers according to the affiliation of the first authors, generated using VOSviewer.

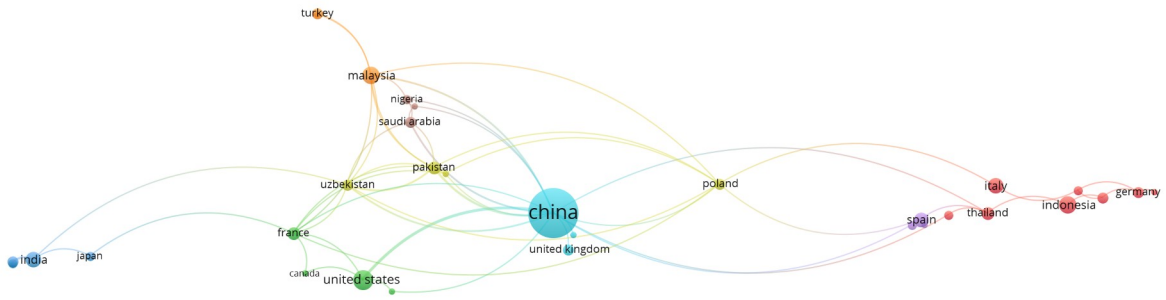

Figure 1: Distribution of scientific papers from the Scopus scientometric database by the key phrases “fiscal incentives” and “green investments” according to author affiliation.

The largest number of papers originated from China (58 documents) and the United States of America (10 scientific papers). Malaysia and Indonesia contributed 7 papers each, Italy and India 6 papers each, and Spain and France 5 papers each. A number of countries, including the United Kingdom, Belgium, and others, accounted for 2 papers each. It is worth noting that the most cited papers are from China, with 952 citations, folsmalled by Malaysia with 282 citations, the United States with 237, Italy with 207, and Belgium with 175. The results of the bibliometric analysis show that the topic of fiscal incentives for green investments is most actively studied in countries with a high level of environmental policy development, investment activity, and state support for the “green” transformation of the economy.

A significant contribution to the study of the role of tax and fiscal instruments in the implementation of environmental policy was made by S. C. Jagers and H. Hammar, who, using Sweden as an example, substantiated the effectiveness of environmental taxation as a tool for reducing negative environmental impact, provided that its public legitimacy is ensured [3]. A similar position is held by L. A. Steenkamp, M. Shafi, and co-authors, who proved that environmental taxes and green tax incentives can have a positive impact on the environmental protection activities of business entities and stimulate the environmentally oriented transformation of the economy [11].

A separate area of research is related to the study of the impact of tax incentives on the investment and innovation activity of enterprises. In particular, J. Mao and C. Wang proved the

existence of a positive relationship between tax benefits and enterprises' environmental investments [4]. These approaches were further developed in the works of C. Wang, P. Chen, Y. Hao, and A. A. Dagestani, as well as Y. Shi and J. Ge, who substantiated the role of fiscal incentives in the development of green technologies, environmental innovations, and the improvement of business competitiveness [5, 7]. At the same time, the authors emphasize that the effectiveness of tax instruments largely depends on enterprises' ability to attract financial resources and implement innovative projects.

In modern scientific literature, increasing attention is also paid to the problems of assessing the effectiveness of fiscal incentives and forming an analytical basis for management decision-making. Thus, A. Celani, L. Dressler, and M. Wermelinger proposed methodological approaches to the systematization and comparison of investment tax incentives across different countries [6]. The importance of taking into account business financial constraints when implementing environmental policy is substantiated in the study by I. Tingbani, S. Salia, J. G. Hussain, and Y. Alhassan [8]. In turn, V. Koval, V. Fostolovych, O. Kubai, F. Tkachyk, L. Prystupa, and O. Laktionova revealed the specific features of managing environmental fiscal revenues and emphasized the need to use modern analytical approaches to increase the effectiveness of environmentally oriented financial policy [12].

Despite significant scientific achievements in the field of environmental taxation, green innovation, and investment incentives, the development of intelligent methods to support decision-making on fiscal incentives for green investments remains insufficiently researched. This highlights the need to develop approaches capable of integrating fiscal, investment, environmental, and innovation parameters into a single analytical system for assessing and forecasting the effectiveness of state incentives.

3. Key influencing factors

Given the need to develop effective mechanisms for the fiscal stimulation of green investments, the use of intelligent approaches to assessing the relationship between budgetary programs, tax and customs instruments, investment activity, and the environmental modernization of the economy is of particular relevance [5, 6]. In modern conditions, environmental taxation, budget financing of the environmental protection sector, as well as tax and customs incentives and budgetary and grant support, are important elements of the system for stimulating the green transition [2, 3]. At the same time, the effectiveness of such instruments is determined not only by the volume of fiscal support but also by their ability to be transformed into real capital investments and current environmental activities of business entities [7, 8].

In this context, it is advisable to develop an integrated system of indicators that combines macro-financial, investment, and incentive-related parameters of the development of the environmental protection sector [9, 10]. The proposed approach involves the use of statistical and linguistic indicators for the further application of fuzzy-set analysis in order to assess the effectiveness of fiscal stimulation of green investments [29-31]. Particular attention is paid to the analysis of the dynamics of environmental tax revenues to the Consolidated Budget of Ukraine, budget expenditures on environmental protection, capital investments by business entities, and current environmental expenditures (Table 1).

Thus, the architecture of indicators for assessing the effectiveness of fiscal incentives for green investments is represented by the folsmalling indicators:

- the amount of environmental taxes paid;
- the dynamics of budget expenditures on environmental protection;
- capital investments by enterprises in environmental protection;
- current expenditures of enterprises on environmental protection;
- the use of fiscal incentives for green investments, including tax, customs, and grant instruments.

Table 1
Indicators for assessing the effectiveness of fiscal incentives for green investments in Ukraine, UAH million, UAH million

Indicators	2018	2019	2020	2021	2022	2023	2024	2025
1. Environmental tax revenues	4921,5	6093	5398	5989	4897,7	4966,1	5387	5605,5
2. Budgetary expenditures on environmental protection	8242,1	9729	9057	10620	5226,7	6395	10384,1	11772,4
3. Capital investments on environmental protection	10074,3	16255,7	13239,6	14113,7	6446,02	8284,03	7806,8	7951,2
4. Current expenditures on environmental protection	24318,0	27480,2	28092,6	30691,2	24126,9	29313,6	34696,3	35974,1

The effectiveness of fiscal incentives for green investment requires systematic assessment, research, analysis, and audit in order to identify shortcomings in their application, enhance the effectiveness of state support, and improve green fiscal policy mechanisms.

4. Model construction

To analyze the effectiveness of fiscal incentives for green investments, it is advisable to use fuzzy logic, since the issue under study is characterized by a significant number of qualitative and partially uncertain factors. Unlike traditional quantitative methods, a fuzzy system makes it possible to take into account not only numerical indicators but also expert assessments, linguistic characteristics, and cause-and-effect relationships between the level of fiscal support, investment activity, and the effectiveness of green projects [15-18].

The construction of a fuzzy system for assessing fiscal incentives for green investments involves determining input and output variables, forming membership functions, developing a rule base, and carrying out a fuzzy inference procedure. The folsmalling indicators can be used as input variables:

- taxes paid (T);
- budget expenditures (B);
- capital investments (C);
- enterprise expenses (E);
- fiscal incentives for green investments (F).

Each of these variables can be described using the linguistic values “small”, “medium”, and “high” [21, 22]. The output variable of the fuzzy system is the level of effectiveness of fiscal incentives for green investments. It is represented by the linguistic values “small efficiency”, “moderate efficiency”, and “high efficiency”. This approach makes it possible to obtain a

generalized assessment of the effectiveness of fiscal instruments [32, 33] and to identify the factors that have the greatest impact on the activation of green investments.

For the assessment, a membership-based model is used, in which the output value can be represented as a function:

$$V = f(T; B; C; E; F) \quad (1)$$

where, T – taxes paid; B – budget expenditures; C – capital investments; E – enterprise expenses; F – fiscal incentives for green investments.

Thus, the use of a fuzzy system provides a comprehensive assessment of fiscal incentives, taking into account economic, institutional, financial, and environmental factors. The proposed approach is appropriate for analyzing situations characterized by incomplete data certainty, where decision-making requires a combination of statistical information and expert judgment. This makes it possible to improve the validity of assessing the effectiveness of state support for green investments and to formulate recommendations for improving fiscal policy in the context of sustainable development. Figure 2 shows a general view of the fuzzy system.

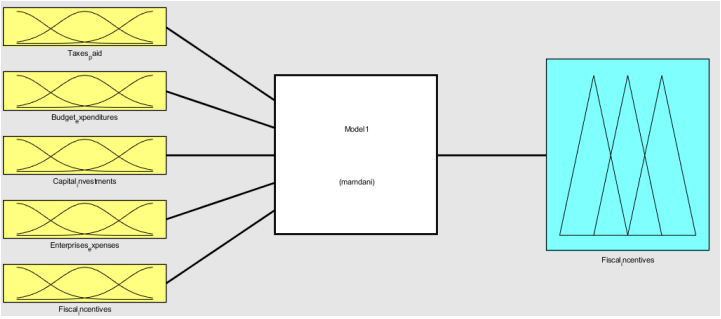

Figure 2: General view of a fuzzy system.

Within the framework of the fuzzy model, the taxes paid indicator should be considered as the amount of environmental taxes paid, reflecting the level of fiscal burden on business entities whose activities affect the environment. This indicator characterizes the financial participation of enterprises in compensating for environmental damage and forming a resource base for the implementation of environmental protection measures. In the fuzzy system, the amount of environmental taxes paid can be represented by the intervals “small”, “medium”, and “high”. Its inclusion makes it possible to assess the extent to which the tax mechanism stimulates enterprises to reduce their harmful impact on the environment and increase green investments [4, 9, 25]. At the same time, an excessive level of environmental taxation without appropriate investment incentives may reduce enterprises’ financial capacity to implement environmental projects. Figure 3 shows the membership function of the taxes paid variable.

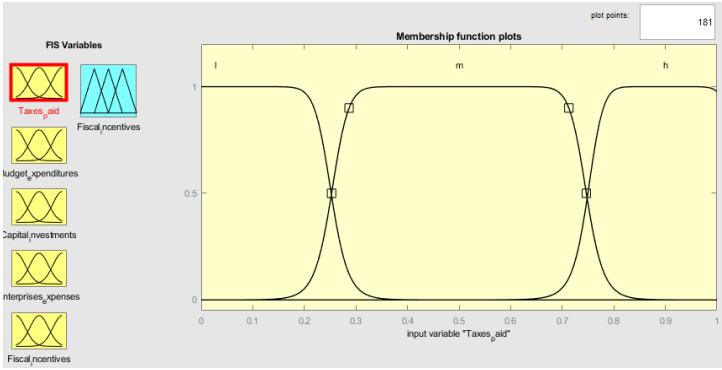

Figure 3: View of the taxes paid variable.

The budget expenditures variable characterizes the dynamics of budget expenditures on environmental protection. This indicator reflects the level of state financial support for environmental measures, environmental programs, and projects aimed at reducing negative environmental impact. In the fuzzy system, the dynamics of budget expenditures can be described using the intervals “small”, “medium”, and “high”. An increase in such expenditures indicates the growing role of the state in stimulating green investments and creating financial prerequisites for sustainable development. Figure 4 shows a general view of the budget expenditures variable.

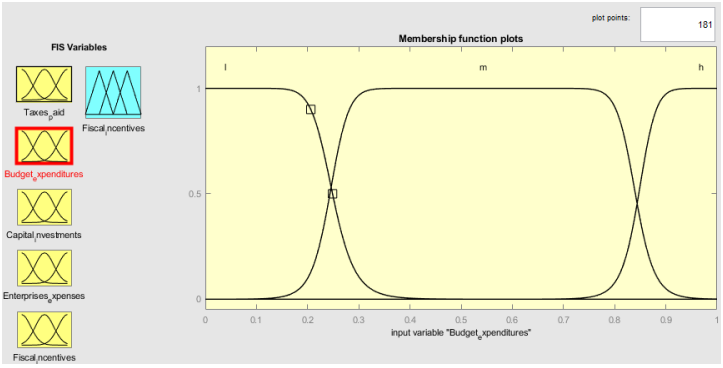

Figure 4: View of the budget expenditures variable.

Within the framework of the fuzzy model, the capital investments variable reflects the volume of capital investments by enterprises aimed at environmental protection. This indicator characterizes the willingness of business entities to invest in production modernization, the introduction of environmental technologies, emission reduction, and the rational use of natural resources. The growth of capital investments in environmental protection measures indicates the increasing practical orientation of business toward green development and enhances the effectiveness of fiscal incentives for green investments. Figure 5 shows a general view of the capital investments variable.

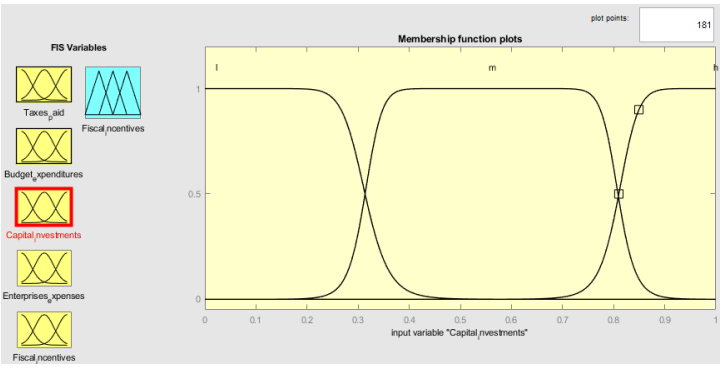

Figure 5: View of the capital investments variable.

Within the framework of the fuzzy model, the enterprise expenses variable characterizes the current expenses of enterprises on environmental protection. This indicator reflects the regular financial expenses of business entities for the maintenance of environmental protection equipment, the treatment of emissions and discharges, waste management, and other environmental measures. To formalize this variable in the fuzzy model, it is advisable to distinguish three assessment intervals: “small”, “medium”, and “high” levels of current expenses. A small level indicates limited participation of enterprises in financing environmental protection measures, a medium level indicates stable but insufficiently intensive expenses on environmental activities, and a high level indicates the active allocation of resources to support and develop environmental protection processes. The growth of current expenses on environmental protection indicates an increase in enterprises’ environmental responsibility and may positively affect the effectiveness of fiscal

incentives for green investments. Figure 6 shows a general view of the enterprise expenses variable.

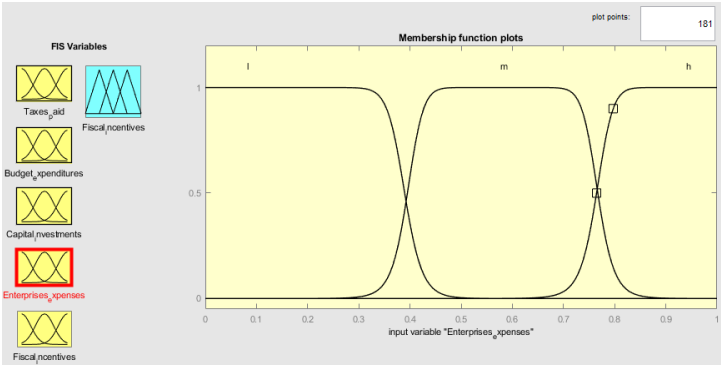

Figure 6: View of the enterprises expenses variable.

The fiscal incentives for green investments variable characterizes the level of use of fiscal incentives aimed at activating green investments. Such incentives include tax benefits, customs preferences, grant support, subsidies, and other instruments of state financial policy that reduce enterprises' costs for implementing environmental projects [19]. An increase in the use of fiscal incentives creates favorable conditions for attracting investment in environmental technologies, production modernization, and the development of an environmentally oriented economy. The dynamics of fiscal incentives for green investments can be described using the intervals "small", "medium", and "high", which reflect the level of use of tax, customs, and grant incentives to support green investments. A small level indicates limited use of such instruments, a medium level indicates their partial use, and a high level indicates active and systematic fiscal support for environmentally oriented investments. Figure 7 shows a general view of the fiscal incentives variable.

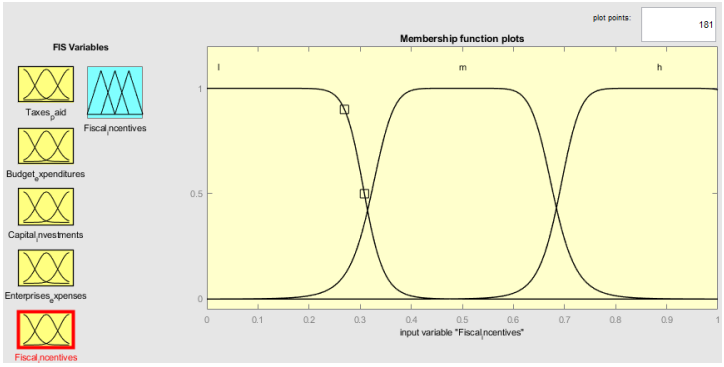

Figure 7: View of the fiscal incentives variable.

The result of the fuzzy model A Model for Assessing the Effectiveness of Fiscal Incentives for Green Investment in Ukraine is a generalized assessment of the effectiveness of fiscal incentives for green investments in Ukraine. The output variable is represented by three levels: "small effectiveness", which indicates an insufficient impact of tax, customs, and grant instruments on the stimulation of green investment; "moderate effectiveness", which reflects the partial effectiveness of fiscal incentives; and "high effectiveness", which characterizes effective and systematic state support for green investments. This approach makes it possible not only to determine the overall level of effectiveness of fiscal policy but also to identify the key factors that have the greatest impact on the development of green investments [23, 24]. Figure 8 shows a general view of the results of the Fiscal Incentives model.

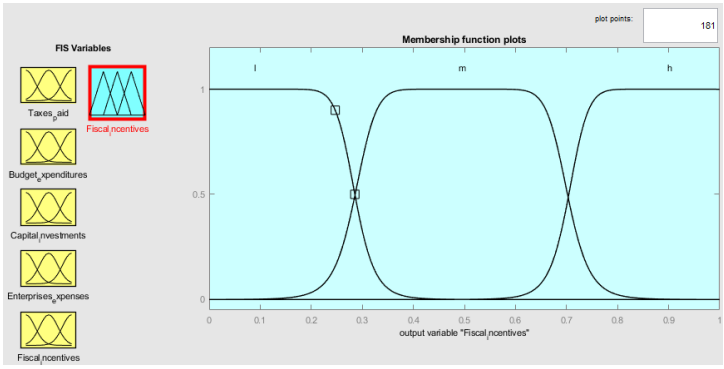

Figure 8: General view of the results of the fuzzy Fiscal Incentives model.

For a fuzzy model, an important stage is the formation of a base of "if–then" rules that reflect the logic of the relationship between input variables and the effectiveness of fiscal incentives for green investments [13, 14]. A total of 1,023 rules were developed to construct the model. These rules make it possible to combine quantitative indicators and expert judgments regarding the impact of environmental taxes, budget expenditures, capital investments, current expenditures of enterprises, and fiscal incentives on the overall level of model efficiency [20, 28]. For example, if the level of fiscal incentives is high, budget expenditures increase, and enterprises' capital investments in environmental protection measures are significant, then the efficiency of incentives for green investment is defined as high. Conversely, if tax, customs, and grant incentives are used to a limited extent, and the investment activity of enterprises in the field of environmental protection is small, then the model result is characterized by small efficiency. Figure 9 shows an example of rule formation for the fuzzy model.

118. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is m) and (Enterprises_expenses is l) and (Fiscal_incentives is l) then (Fiscal_incentives is m) (1)
119. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is m) and (Enterprises_expenses is l) and (Fiscal_incentives is m) then (Fiscal_incentives is m) (1)
120. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is m) and (Enterprises_expenses is l) and (Fiscal_incentives is h) then (Fiscal_incentives is m) (1)
121. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is m) and (Enterprises_expenses is m) and (Fiscal_incentives is l) then (Fiscal_incentives is m) (1)
122. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is m) and (Enterprises_expenses is m) and (Fiscal_incentives is m) then (Fiscal_incentives is m) (1)
123. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is m) and (Enterprises_expenses is m) and (Fiscal_incentives is h) then (Fiscal_incentives is m) (1)
124. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is m) and (Enterprises_expenses is h) and (Fiscal_incentives is l) then (Fiscal_incentives is m) (1)
125. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is m) and (Enterprises_expenses is h) and (Fiscal_incentives is m) then (Fiscal_incentives is m) (1)
126. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is m) and (Enterprises_expenses is h) and (Fiscal_incentives is h) then (Fiscal_incentives is m) (1)
127. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is h) and (Enterprises_expenses is l) and (Fiscal_incentives is l) then (Fiscal_incentives is m) (1)
128. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is h) and (Enterprises_expenses is l) and (Fiscal_incentives is m) then (Fiscal_incentives is m) (1)
129. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is h) and (Enterprises_expenses is l) and (Fiscal_incentives is h) then (Fiscal_incentives is m) (1)
130. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is h) and (Enterprises_expenses is m) and (Fiscal_incentives is l) then (Fiscal_incentives is m) (1)
131. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is h) and (Enterprises_expenses is m) and (Fiscal_incentives is m) then (Fiscal_incentives is m) (1)
132. If (Taxes_paid is m) and (Budget_expenditures is m) and (Capital_investments is h) and (Enterprises_expenses is m) and (Fiscal_incentives is h) then (Fiscal_incentives is m) (1)

Figure 9: Example of forming fuzzy model rules.

The constructed fuzzy model works correctly, which is confirmed by the results shown in Figure 10.

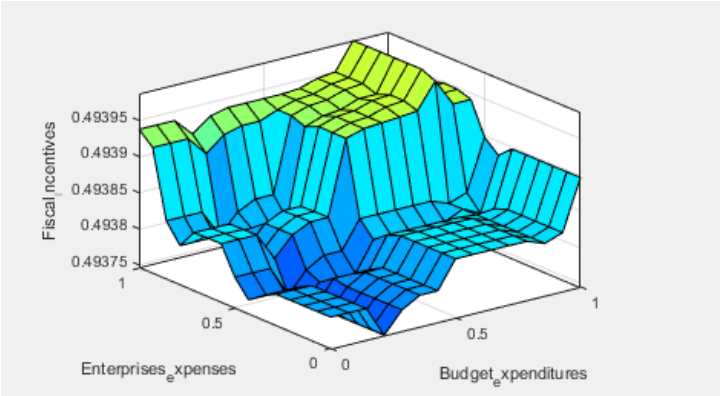

Figure 10: Example of Enterprises expenses and Budget expenditures relationship.

The proposed fuzzy model demonstrates the correctness of its work, since the obtained results are consistent with the logic of the formed input variables, membership functions, and rule base.

5. Implementation

The practical value of the study lies in the possibility of using the proposed intelligent method to improve the formation and implementation of fiscal instruments aimed at stimulating green investment under martial law and during the post-war reconstruction of Ukraine, as well as in implementing the principles of sustainable development and adapting them to the strategic priorities of European integration. The proposed approach can be used by the Ministry of Finance of Ukraine to improve green fiscal policy mechanisms, assess the effectiveness of tax and budgetary incentives, and enhance the efficiency of directing financial resources toward environmental modernization. The results of the study can also be applied by the Ministry of Environmental Protection and Natural Resources of Ukraine in monitoring the financial support of environmental protection measures, assessing the effectiveness of green transition instruments, and determining the priorities of the state's environmental policy. The proposed fuzzy model can also be used in the audit of fiscal incentives for green investment, as it provides an analytical basis for assessing the consistency, effectiveness, and validity of state support instruments. Its application enables auditors to identify weaknesses in the use of tax, budgetary, customs, and grant incentives, as well as to evaluate their impact on the ecological modernization of Ukraine's economy.

6. Conclusions

The study substantiates the relevance of assessing the effectiveness of fiscal incentives for green investment in Ukraine in the context of martial law, post-war recovery, European integration processes, and the need to transition to a sustainable development model. It has been established that fiscal instruments, in particular environmental taxation, budget expenditures, tax and customs incentives, grant support, and subsidies, play an important role in creating the financial prerequisites for the ecological modernization of the economy. The paper proposes a fuzzy model for assessing the effectiveness of fiscal incentives for green investment in Ukraine. The input variables of the model include the amount of environmental taxes paid, budget expenditures on environmental protection, enterprises' capital investments, enterprises' current expenditures on environmental protection activities, and the level of use of fiscal incentives for green investment. The output variable is the level of effectiveness of fiscal incentives for green investment, represented by the linguistic values of "small efficiency", "moderate efficiency", and "high efficiency".

The proposed fuzzy system makes it possible to formalize cause-and-effect relationships between fiscal, investment, and environmental indicators. The developed "if–then" rule base enables scenario analysis of the impact of individual factors on the effectiveness of state support for green investment. The correctness of the model is confirmed by the consistency of the obtained results with the logic of the input variables, membership functions, and the developed rule base. The practical value of the proposed approach lies in the possibility of using it to increase the validity of management decisions in the field of green fiscal policy. The model can be used to assess the effectiveness of tax and budgetary incentives, determine priorities for financing environmental protection measures, improve mechanisms of state support for green investment, and form an analytical basis for the ecological modernization of Ukraine's economy. In addition, the proposed fuzzy model can be applied in the audit of fiscal incentives for green investment as a tool for analytically verifying their effectiveness, validity of application, and impact on ecological modernization processes.

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Declaration on Generative AI

During the preparation of this work, the authors used ChatGPT, Grammarly in order to grammar and spelling check. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the publication's content.

References

[1] Scopus, Search results for scientific papers from the scientometric database Scopus using the key phrases “fiscal incentives” and “green investments.” URL: https://www.scopus.com/pages/search/publications?searchId=28a83353-46a1-4941-a777-8e69ac3f1993, accessed: 2026-06-02.

[2] M. Shafi, C. S. Ramos-Meza, V. Jain, et al., The dynamic relationship between green tax incentives and environmental protection, Environmental Science and Pollution Research 30 (2023) 32184–32192. doi: 10.1007/s11356-023-25482-y.

[3] S. C. Jagers, H. Hammar, Environmental taxation for good and for bad: the efficiency and legitimacy of Sweden’s carbon tax, Environmental Politics 18(2) (2009) 218–237. doi: 10.1080/09644010802682601.

[4] J. Mao, C. Wang, Tax incentives and environmental protection: evidence from China’s taxpayer-level data, China Finance and Economic Review 4 (2016) 14. doi: 10.1186/s40589-016-0040-0.

[5] Y. Shi, J. Ge, The role of government fiscal and tax incentives in green technology innovation and enterprise development: implications for human health and hygiene, Frontiers in Public Health 12 (2025) 1502856. doi: 10.3389/fpubh.2024.1502856.

[6] A. Celani, L. Dressler, M. Wermelinger, Building an Investment Tax Incentives Database: Methodology and Initial Findings for 36 Developing Countries, OECD Working Papers on International Investment No. 2022/01, OECD Publishing, Paris, 2022. doi: 10.1787/62e075a9-en.

[7] C. Wang, P. Chen, Y. Hao, A. A. Dagestani, Tax incentives and green innovation: the mediating role of financing constraints and the moderating role of subsidies, Frontiers in Environmental Science 10 (2022) 1067534. doi: 10.3389/fenvs.2022.1067534.

[8] I. Tingbani, S. Salia, J. G. Hussain, Y. Alhassan, Environmental tax, SME financing constraint, and innovation: evidence from OECD countries, IEEE Transactions on Engineering Management 70(3) (2023) 1006–1025. doi: 10.1109/TEM.2021.3110812.

[9] M. Sharkadi, Methodology for developing information technology for security-oriented management of socio-economic systems based on fuzzy logic, Computer Systems and Information Technologies (3) (2024) 86-91. doi: 10.31891/csit-2024-3-11.

[10] G. Kou, S. Eti, S. Yüksel, H. Dinçer, M. Acar, E. Ergün, H. Çetinkaya, Advancing financial innovation in energy poverty solutions: a Koch snowflake-based fuzzy decision support system, Financial Innovation 12 (2026) 1. doi: 10.1186/s40854-025-00896-4.

[11] L. A. Steenkamp, Transitioning to clean energy – an overview of energy taxes in BRICS, in: Proceedings of the 2019 International Conference on Clean Electrical Power (ICCEP), Otranto, Italy, 2019, pp. 656–663. doi: 10.1109/ICCEP.2019.8890150.

[12] V. Koval, V. Fostolovych, O. Kubai, F. Tkachyk, L. Prystupa, O. Laktionova, Financial outsourcing in the analysis of environmental fiscal revenue management, Financial and Credit Activity: Problems of Theory and Practice 6(53) (2023) 112–127. doi: 10.55643/fcaptp.6.53.2023.4155.

[13] O. Desyatnyuk, F. Tkachyk, S. Sachenko, O. Chereshnyuk, V. Karpinets, Modeling tax administration efficiency in the context of digitalization of public finances, Journal of European Economy 25(1) (2026) 136–154. URL: https://jeej.wunu.edu.ua/index.php/enjee/article/view/1914.
[14] N. Vasylkiv, L. Dubchak, A. Sachenko, Estimation method of information system functioning quality based on the fuzzy logic, in: Proceedings of the Modern Machine Learning Technologies and Data Science Workshop 2020 (MoMLeT+DS 2020), CEUR Workshop Proceedings, CEUR-WS.org, 2020, pp. 40–56.
[15] G. Mussagulova, K. Baisholanova, E. Tulegenova, A. Adranova, G. Yensebayeva, Effectiveness of ICT in investment policy decision-making for economic entities, International Journal of Computing 23(4) (2024) 655–662. doi: 10.47839/ijc.23.4.3764.
[16] O. Ivanov, V. Iatsiuta, V. Kobets, Financial video analysis using natural language processing: an empirical study of stock forecast, International Journal of Computing 25(1) (2026) 71–81. doi: 10.47839/ijc.25.1.4490.
[17] I. Lytvinchuk, B. Savenko, S. Danchuk, Heating optimization system in a smart home based on fuzzy logic and integration with cloud services, Computer Systems and Information Technologies (1) (2025) 16-28. doi: 10.31891/csit-2025-1-2.
[18] O. Sai, K. Krasnikov, Fuzzy model of electricity control with wireless information processed on GPU, Computer Systems and Information Technologies (3) (2024) 44-50. doi: 10.31891/csit-2024-3-6.
[19] J. E. Hajlaoui, W. Khemili, M. N. Omri, Deep learning and fuzzy logic integration for virtual network function deployment, Journal of Network and Systems Management 34 (2026) 50. doi: 10.1007/s10922-025-10020-7.
[20] A. Slotkienė, J. Miliauskaitė, R. Karbauskaitė, Fuzzy-based security requirements quality assessing: comparison of security experts and generative AI, Computer Standards & Interfaces 97 (2026) 104137.
[21] A. Vitetta, Advancing path choice in transport systems: insights from fuzzy logic models, Sustainability 18(7) (2026) 3236. doi: 10.3390/su18073236.
[22] B. Tarle, M. Akkalaksmi. Improving classification performance of neuro-fuzzy classifier by imputing missing data, International Journal of Computing 18(4) (2019) 495–501. doi: 10.47839/ijc.18.4.1619.
[23] E. Fedorov, M. Leshchenko, T. Sakhno, V. Pasenko, O. Kravchenko, Marketing decision support system based on fuzzy trained associative rules expert system, Computer Systems and Information Technologies (3) (2025) 151-159. doi: 10.31891/csit-2025-3-16.
[24] N. Cobelli, I. Confente, V. G. Kuppelwieser, Configurational pathways to professional service innovation: a fuzzy set analysis of provider adoption decisions, Journal of Service Management 37(6) (2026) 119-145.
[25] S. Eti, S. Yüksel, H. Dinçer, et al., Machine learning-enhanced fuzzy framework for prioritizing financial risk management techniques in renewable energy projects, Financial Innovation 12 (2026) 85. doi: 10.1186/s40854-026-00917-w.
[26] F. Hosseinali, A. Namvari, A. Sharifi, H. Rabiei-Dastjerdi, Highlighting concealed communities: detection of urban informal settlements using space syntax method, fuzzy model, and high-resolution imagery, Humanities and Social Sciences Communications 13 (2026) 108. doi: 10.1057/s41599-025-06413-3.
[27] J. Cifuentes-Faura, H. Alofaysan, M. Radulescu, et al., Dynamic spillover effect among carbon finance, bitcoin, and green energy markets: a novel decomposed connectedness and portfolio analysis, Financial Innovation 12 (2026) 109. doi: 10.1186/s40854-026-00922-z.
[28] M. Ahmad, Z. Ahmed, K. Wang, Investigating the interplay between green finance, eco-innovation, natural resources, and environmental sustainability: evidence from panel quantile

and machine learning approaches, Financial Innovation 12 (2026) 64. doi: 10.1186/s40854-025-00864-y.

[29] O. Chereshnyuk, O. Desyatnyuk, S. Sachenko, H. Liakhovych, R. Brykhansky, Internal audit of the sales system: a fuzzy-multiple approach, in: Proceedings of the 13th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS 2025), Gliwice, Poland, IEEE, 2025, pp. 346–351. doi: 10.1109/IDAACS68557.2025.11322186.

[30] O. I. Beley, S. I. Sachenko, The information system of control risks, in: Proceedings of the International Workshop on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS'2001), Crimea, Ukraine, IEEE, 2001, pp. 270–274. doi: 10.1109/IDAACS.2001.942029.

[31] A. S. Ahmed, O. N. Basheer, H. A. Salah, Breast tumors diagnosis using fuzzy inference system and fuzzy C-means clustering, International Journal of Computing 20(4) (2021) 551–559. doi: 10.47839/ijc.20.4.2443.

[32] S. Jaafari, M. Nassiri, R. Mohammadi, Traffic-aware routing with software-defined networks using reinforcement learning and fuzzy logic, International Journal of Computing 21(3) (2022) 318–324. doi: 10.47839/ijc.21.3.2687.

[33] O. Sutiahin, O. Cherednichenko. LLM-Driven Query Generation For Graph-Based Business Intelligence: Towards a collaborative knowledge retrieval tool. Computer Systems and Information Technologies, 4 (2025) 103–110. https://doi.org/10.31891/csit-2025-4-11