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CONCEPTUAL MODEL OF SUSTAINABLE FINANCIAL INSTRUMENTS FOR ENSURING ENVIRONMENTAL-ECONOMIC RESILIENCE UNDER DIGITALIZATION AND GLOBALIZATION

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ABSTRACT

This paper aims to develop a comprehensive conceptual model for the functioning of sustainable financial instruments to ensure the environmental-economic resilience of national economies under digitalization and globalization. It empirically evaluates the complex time-lagged effects of green bond issuances and investigates the moderating role of institutional, technological, and socio-economic context determinants.

The empirical findings reveal a distinct two-phase, time-delayed impact of green bond issuances on macro-resilience. In the short term, green bond issuances induce a statistically significant temporary reduction in environmental-economic resilience due to initial capital deployment costs and increased debt service burdens. In the long term, absolute green bond issuance exerts a significant positive effect, proving their efficacy for structural ecological transition. Conversely, an increasing ratio of green bonds to GDP causes persistent short-term negative pressures, highlighting debt sustainability risks if green debt scales too rapidly. Furthermore, Network Readiness acts as a robust inhibitor of resilience across all time horizons, indicating the negative ecological footprint of digital infrastructure and AI-driven greenwashing risks. Globalization demonstrates a protective buffering capacity against short-term debt shocks, while standard institutional metrics show no direct statistical significance.

The study's primary outcome is the development of a multidimensional conceptual model of sustainable financial instruments functioning. It integrates digital technologies and a two-tier system for preventing greenwashing to effectively transform sustainable finance into macroeconomic resilience. Given that empirical analysis has demonstrated the existence of a time lag and short-term risks of debt overhang, policy recommendations advocate a systemic shift from aggressive volume expansion to the measured, regulated issuance of green bonds. The state strategy should combine rigorous digital monitoring of the targeted use of funds raised through sustainable financial instruments with the development of environmental safeguards for digital infrastructure, thereby minimizing financial shocks and ensuring the long-term growth of eco-economic resilience.

Keywords: sustainable finance, green bonds, environmental-economic resilience, digitalization, globalization, conceptual model, macroeconomic stability, financial instruments, transformations, sustainable development

JEL Classification: E44, E63, F42, F65, G23, O11, Q56

INTRODUCTION

The current stage of global economic transformation is characterized by a fundamental rethinking of the economic growth paradigm, driven by the pressure of intensifying planetary environmental limits, systemic climate risks, and the degradation of natural capital. Garcia-Jorcano & Sanchis-Marco (2025) demonstrate that climate risks are becoming a source of systemic risk, affecting both overall economic resilience and the stability of the financial system. Traditional linear economic models have exhausted their

potential, giving way to the concept of eco-economic resilience, which entails the capacity of national macrosystems to adapt, recover, and develop amidst stringent environmental constraints without sacrificing economic well-being.

Achieving eco-economic sustainability is impossible without considering the architecture of two pivotal global-scale processes – digitalization and deepening globalization – which are fundamentally transforming the landscape of international financial and production systems. Digitalization acts as a powerful catalyst for structural change, providing unique technological tools to optimize resource use, enhance energy efficiency, and implement fundamentally new circular economy models. The integration of artificial intelligence, Big Data, the Internet of Things (IoT), and distributed ledger technology (blockchain) creates qualitatively new opportunities for end-to-end environmental monitoring, precise car-bon footprint measurement, and the verification of non-financial (ESG) reporting. However, digitalization also presents a hidden methodological paradox: the rapid deployment of digital infrastructure and the expanding scale of data centers and electronic waste generate a significant environmental footprint, necessitating a balanced assessment of the overall environmental impact.

The process of globalization facilitates the rapid transfer of capital, technologies, and management practices across borders, shaping a unified global market for sustainable investment. Deepening economic integration enables the mobilization of resources from international financial institutions and private investors to fund large-scale environmental and climate projects in transition economies and developing regions. However, the flip side of globalization includes the exponential growth of cross-border environmental externalities, the relocation of resource-intensive and polluting industries to countries with lax environmental regulations, and the heightened vulnerability of national financial systems to external economic and geopolitical shocks.

At the intersection of digitalization and globalization, sustainable financial instruments such as green and social bonds, ESG-lending, environmental sovereign wealth funds, sustainable derivatives, and digital eco-assets are emerging as key connecting links and mechanisms for resource reallocation. Financial innovations underpinned by digital infrastructure (e.g., the tokenization of green bonds or automated online monitoring of the use of earmarked funds) significantly reduce transaction costs, overcome information asymmetry, and minimize the risks of environmental data falsification ("greenwashing") in international markets. The strategic role of sustainable corporate financial development is demon-strated by empirical studies confirming a positive link between ESG performance and corporate financial resilience (Sastroredjo & Suganda, 2026).

The importance of developing green finance policies continues to grow, shaping the preferences of capital owners. Research by Takahashi & Shino (2025) demonstrated that banks' perception of a borrowing firm's credit risk is influenced by its greenhouse gas emissions; banks reduce lending volumes to "brown" firms or impose higher credit risk premiums on them. Conversely, scholars have shown that a higher level of credit market development in a country is closely associated with improved corporate ESG performance (Muchenje et al., 2025). A notable shift in investor preferences is also evident in the stock market, where rising demand for "green" assets enables companies with high ESG performance to generate abnormal excess returns (Postiglione et al., 2026). At the same time, using the banking sec-tor as a case study, Liaqat et al. (2026) demonstrate that the positive impact of ESG on financial stability depends significantly on national culture and the level of institutional development.

Despite the rapid growth of the green bond and sustainable loan markets, a systemic conflict remains unresolved in contemporary academic discourse and public administration practice regarding precisely how the mobilization of sustainable finance, the level of digital readiness, and the degree of globalization influence actual environmental-economic outcomes. The lack of unified methodological approaches for assessing the complex, non-linear interplay of these fac-tors hinders the formulation of effective public strategies and the development of adaptive conceptual models. This creates an urgent academic and practical need for in-depth research into the mechanisms by which sustainable financial instruments can steer national economies onto a trajectory of long-term environmental-economic resilience amidst digitalization and globalization.

LITERATURE REVIEW

An analysis of contemporary scientific literature has shown that the development of sustainable finance is in its formative stage, which entails active research into its interrelationships with key economic processes. According to Ryszawska (2020), the transition from traditional to sustainable finance is a complex process that includes economic, environmental, social, and digital dimensions. Compared to the traditional regime of finance, which is profit-oriented, limited in social and environmental responsibility, short-term, and considers only narrow risks, the concept of green finance pro-vides a mission-oriented approach with sustainable values, innovative technologies, and full risk consideration in the long-term prospect.

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At the same time, the restructuring of the financial system is accompanied by changes in the types and forms of financial instruments. Panagopoulos & Tzionas (2023) highlight the importance of innovative sustainable financial instruments, which are crucial to change the paradigm of investment perception and contribute to a sustainable environment for companies' development. It should be noted that a distinctive feature of sustainable finance in-vestment priorities is not only the analysis of achievable financial results but also the assessment of the societal impact of sustainable investment projects. Research findings by Hasebe (2026) demonstrate that blended finance for sustainable development projects in the energy sector is a significant factor in facilitating the energy transition in developing economies. At the same time, a country's institutional readiness is a crucial prerequisite for the effective mobilization of capital.

A significant number of scholarly works are devoted to the study of the prerequisites for the development of sustainable finance. Grechyna & Ofori (2025) investigated 31 potential determinants of green finance development. They found the importance of a country's global integration. Thus, a high level of globalization and the growth of multilateral flows encourage the scale of green finance, as well as official development assistance. On the other hand, trade openness is a factor that inhibits green financial flows. Economic development is also very important for green finance establishment. However, a high level of GDP per capita is a deterrent factor for sustainable transformation of the financial system. Among macroeconomic indicators, the highest stimulus for green finance is total population, while unemployment is an obstacle to its development. The environmental landscape was detected as a crucial prerequisite. Thus, green finance flows grow faster under conditions of high climate change vulnerability. High quality of the institutional environment, measured by government effectiveness and rule of law, also contributes to green finance development. On the other hand, peculiarities of financial development and entrepreneurship turned out to be unimportant factors for the emergence of green finance. The identified prerequisites demonstrate that the conceptual framework for the functioning of sustainable finance must systematically consider the specific characteristics of the national economy, which determine the multi-channel impact of the financial system's paradigm shift. At the same time, further research is needed to identify the factors capable of strengthening or weakening the potential impact of sustainable finance on the country's progress toward achieving the Sustainable Development Goals.

The results of a study on the sustainable finance research landscape (Rabbani et al., 2026) demonstrated that green bonds and sustainable investments are the most prevalent financial instruments. Endri et al. (2025) found that volumes of green bonds emissions highly depended heavily on bond characteristics (coupon, rating, and maturity). On the other hand, oil prices and exchange rates are important external factors that define green bond issuance. Research by Poggensee (2025) has demonstrated that the stock market reacts positively to the issuance of green bonds, particularly those with a high likelihood of achieving their issuance objectives and sustainability-linked payout targets by generating abnormal returns. Conversely, empirical studies (Arcuri et al., 2026) have shown that lending to "green" corporations entails higher assessed credit risk, thereby increasing borrowing costs relative to market averages. This underscores the importance of developing a state strategy for green finance management to ensure the sustainable development of the national economy.

Sustainable finance has a huge impact on sustainable development progress. According to the results of research for East Asian countries, the growth of the green finance market value boosts the sustainable development of industrial and agricultural sectors, particularly through eco-innovations and technologies (Shi & Yang, 2025). On the other hand, the sustainable finance emergency is often associated with the development of digital instruments. It is worth noting the conflicting findings regarding the impact of digital finance development on the national economy. Specifically, re-searchers have demonstrated that, unlike traditional financial inclusion, which positively affects economic growth, digital financial inclusion tends to suppress it (Pal et al., 2025). Financial inclusion, particularly through fixed capital accumulation, serves as a significant driver of sustainable development (Chen et al., 2026). At the same time, the development of digital finance and cryptocurrencies in particular generates negative environmental externalities due to increased energy consumption and the accelerated generation of e-waste (Hu et al., 2026). Moreover, researchers have shown that, unlike financial development, which has a positive impact on sustainable development, digitalization leads to an increase in carbon footprint, consumption of natural resources, and environmental degradation (Nguyen & Le, 2026). At the same time, research into the direct impact of digital finance has shown that its development has some environmental benefits. Thus, expanding digital financial coverage and increasing the depth of its use significantly reduces carbon emissions, and this impact is more intense in regions with limited financial accessibility (Zhao et al., 2026). However, it should be noted that the spread of digital finance is constrained by a number of social, behavioral, regulatory, and economic barriers; to overcome these, governments need to address issues regarding financial and digital literacy, the harmonization of regulatory frameworks, the integration of digital finance platforms, and cyber risk management (Trotta et al., 2026).

Despite the rapid development of sustainable finance, there are significant barriers to its scaling. Sharma et al. (2026) highlight four major types of challenges that inhibit the implementation and efficiency of sustainable financial instruments:

the financial gap between sustainable investment projects and available capital; greenwashing risks by issuers of sustainable instruments; lack of criteria and measures of ESG-conformity; lack of public awareness. Dev et al. (2025) aggregate the main components of the sustainable finance concept that are crucial for their development: strategic policy and principles of green finance, methods of impact measurement, environmental and financial risk management, domestic and international sustainable financial instruments. In this context, M S & Siddiqui (2023) emphasize the im-portance of green finance regulation, which should include clear criteria and definitions of green financial instruments, rules and directions of information disclosure, procedures and regime of green financing, and coordination of financial and environmental policies. The results of an empirical study conducted by Trotta et al. (2026) showed that equity Exchange Traded Funds with ESG labels were generally more climate-resilient than their conventional peers. However, their sustainability is mainly influenced by the geographical and sectoral allocation strategy. In addition, increased greenwashing risks were found in the activities of ESG-labelled Exchange Traded Funds. This creates an additional argument for a more stringent policy of sustainable finance.

Based on the results of the Green Finance Reform progress in China investigation, Tan et al. (2026) found that government policy should concentrate not only on pollution reduction but also consider sustainability-risk balance. To re-duce budgetary pressure on sustainable investment projects, local governments must mix public-private partnerships, market green instruments, and public services. Digital infrastructure development is recognized as a crucial factor of sustainable investment absorptive capacity, ensuring data integration and green finance implementation monitoring.

The conducted analysis confirms that the use of sustainable financial instruments and the development of digital finance have greater potential to influence the progress of sustainable development, specifically for developing economies. At the same time, contradictory results obtained in the course of empirical studies testify that the impact of sustainable financial instruments on the development of the national economy is ambiguous. That is why, in the context of the development of the concept of sustainable finance, there is a need to deepen the study of the environmental and economic consequences of their functioning.

AIMS AND OBJECTIVES

The aim of the article is to develop a comprehensive conceptual model of the functioning of sustainable financial instruments to ensure the environmental and economic resilience of national economies amidst the megatrends of digitalization and globalization, as well as to empirically assess temporal effects and the role of institutional and technological prerequisites in realizing this impact. This aim enabled the formulation of the key research objectives:

- **RO1:** To substantiate the theoretical and methodological basis of the relationship between the issuance of sustainable financial instruments and the level of a country's environmental-economic resilience, considering the time horizon of this impact.
- **RO2:** To construct and calculate an integral index of environmental-economic resilience based on a balanced set of economic and environmental indicators.
- **RO3:** To investigate the impact of green bond issuance on ensuring the environmental and economic resilience of the national economy in the short and long term.
- **RO4:** To empirically analyze the regulating and controlling role of contextual determinants (levels of digitalization, globalization, the institutional environment, and socio-economic development) in the process by which sustainable financial instruments influence environmental-economic resilience.
- **RO5:** To develop a multidimensional conceptual model of sustainable financial instruments functioning to ensure environmental-economic resilience.

METHODS

The study aims to determine the impact of sustainable financial instruments on ensuring the country's environmental and economic resilience. Its execution involves the development of an economic-mathematical model. Based on theoretical conceptualization, the model's development incorporates a number of key hypotheses:

- **H1:** The growth of the absolute volumes of sustainable financial instruments issuance has a positive impact on the country's integral level of environmental-economic resilience.

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- **H2:** An increase in the relative level of sustainable financial instrument issuance as a share of GDP is a more significant determinant of enhanced eco-economic resilience than absolute volumes, as it reflects the degree of the national financial system's environmental transformation without risk to debt sustainability.
- **H3:** The positive effect of issuing sustainable financial instruments manifests with a time lag, due to the duration of the investment environmental project life cycle.
- **H4:** A higher level of digital readiness and technological infrastructure development in a country enhances the positive impact of green finance on eco-economic resilience by increasing transparency and inclusivity and reducing information asymmetry (thereby preventing greenwashing).
- **H5:** The country's high level of globalization facilitates the attraction of international green capital and advanced technologies, reinforcing the positive impact of issuing sustainable financial instruments.
- **H6:** The effectiveness of transforming mobilized green capital into long-term environmental-economic resilience depends on the quality of the institutional environment and the level of national wealth, which determine the state's ability to allocate resources judiciously and withstand political or economic shocks.

An analysis of the existing methodological framework indicated that regression modeling is an appropriate research tool. Current trends in the sustainable financial instruments market development revealed that green bonds are the most widely used instruments. Consequently, the issuance of green bonds by country was selected as the key factor variable (International Monetary Fund, 2026). Based on available data, a sample of countries was selected based on the largest bond issuance volumes and annual frequency. Furthermore, the sample selection prioritized the diversification of countries across regions and levels of economic development. Accordingly, the study's data set comprises 46 countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Ukraine, Australia, Brazil, Canada, China, India, Japan, Rep. of Korea, Mexico, New Zealand, Norway, Philippines, Singapore, South Africa, Switzerland, United Arab Emirates, United Kingdom, United States, Vietnam).

Given the limited information base for comprehensively measuring environmental-economic resilience, an integral index combining environmental and economic components was developed to assess it as the study's outcome variable. The following list of indicators was formulated to measure economic resilience:

1. GDP growth, annual %.
2. Current account balance (% of GDP).
3. Gross capital formation, % of GDP.
4. Foreign direct investment, net inflows, % of GDP.
5. Total reserves in months of imports.
6. Trade, % of GDP.
7. Inflation, consumer prices, annual %.
8. Unemployment, total, % of total labor force.
9. Eight indicators have also been selected to measure environmental resilience:
    - Forest area, % of land area.
    - Alternative and nuclear energy, % of total energy use.
    - Carbon intensity of GDP, kg CO2e per constant 2015 USD of GDP.
    - Total greenhouse gas emissions excluding LULUCF, % change from 1990.
    - Renewable internal freshwater resources per capita, cubic meters.
    - Combustible renewables and waste, % of total energy.
    - Fertilizer consumption, kilograms per hectare of arable land.
    - Arable land, % of land area.

The study period covers the years 2000–2025.

The methodology for constructing the developed index involves applying the principal component analysis (PCA) method to input data that have been normalized using the Z-score method, while accounting for the direction of each input

indicator's influence on the aggregate index. The suitability of the dataset for constructing the aggregate index was assessed using the Kaiser-Meyer-Olkin (KMO) criterion. Initial testing revealed the need to refine the input dataset to ensure its suitability for further analysis. Consequently, two economic parameters (current account balance and trade) and two environmental parameters (combustible renewables and waste, and arable land) were excluded from the original sample. In the subsequent stage, the principal component analysis method was applied to the refined dataset. Based on the Kaiser criterion and the cumulative variance criterion, five principal components were selected to serve as the basis for determining weighting coefficients, and the aggregate index was constructed using the previously normalized values of the input indicators.

At the same time, it is worth noting that the impact of sustainable financial instruments on ensuring environmental-economic resilience is largely determined by the country's existing preconditions and the specific characteristics of its national economy; these factors can either amplify or negate the expected effects of issuing such instruments. Therefore, it is appropriate to include control variables in the model that reflect the economic and institutional landscape regarding the use of sustainable financial instruments within the country. According to Paul et al. (2026), fintech plays a significant role in the development of sustainable finance by fostering inclusivity, transparency, and the accessibility of financial services. Consequently, to account for the impact of digital infrastructure development on deepening financial inclusion within the context of ensuring eco-economic resilience, the Network Readiness Index (Portulans Institute, 2025) has been included in the model. This indicator reflects the readiness of the government, society, and the country's technological sector for digital transformation. According to Balsalobre-Lorente et al. (2026), globalization and financial development demonstrate a positive synergy in terms of their potential to reduce the environmental footprint of the national economy. To account for the level of national economic globalization, the KOF Globalisation Index (KOF Swiss Economic Institute, 2026) was incorporated into the model. This index encompasses economic, political, and social globalization, thereby capturing a country's capacity to engage with global investment capital and society's readiness to implement international sustainable development investment projects. Researchers have demonstrated that, among internal factors, socio-economic parameters such as national wealth and access to international markets exert the greatest influence on the adoption of climate bonds (Chavarría-Flores & Warren, 2024). To account for this aspect, the model incorporates the indicator of Gross National Income (GNI) per capita (World Bank, 2026). This parameter captures the disparities in economic development levels among the sampled countries, reflecting a society's economic capacity to transition from meeting basic needs to prioritizing long-term sustainable development. The importance of the regulatory environment in facilitating the corporate "green" transition has been repeatedly confirmed by researchers; specifically, key components include the presence of incentive mechanisms and the assurance of public participation and engagement with regulatory bodies (Zhang et al., 2025). Accordingly, Government Effectiveness and Political Stability (World Bank, 2026) were selected as key parameters to characterize a country's institutional capacity for the effective use of sustainable financial instruments. Indeed, the quality of the institutional environment and political stability largely determine the investment priorities of capital owners. Thus, the developed model looks as follows:

$$EERI_{it} = \beta_0 + \beta_1 GreenBond_{it} + \beta_2 NRI_{it-1} + \beta_3 KOFGI_{it-1} + \beta_4 GNIpc_{it} + \beta_5 PolStab_{it} + \beta_6 GovEff_{it} + \varepsilon, \quad (1)$$

where $EERI_{ij}$ – environmental-economy resilience index in the country i for the period t; $GreenBond_{it}$ – Green Bond Issuances in the country i for the period t, USD billion; NRI_{it-1} – Network Readiness Index in the country i for the period t-1; $KOFGI_{it-1}$ – KOF Globalisation Index in the country i for the period t-1; $GNIpc_{it}$ – gross national income per capita in the country i for the period t, constant 2015 USD; $GovEff_{it}$ – Government Effectiveness estimate in the country i for the period t, constant 2015 USD; $PolStab_{it}$ – Political Stability estimate in the country i for the period t, constant 2015 USD; β_0-β_6 – regression coefficients; ε – measurement and specification error.

At the same time, to facilitate a systems analysis, a model has been developed to determine the impact of the share of "green" bond issuance in a country's GDP on its level of eco-economic resilience, unlike the indicator of the absolute volume of "green" bonds, which illustrates the scale of environmental project implementation. This relative metric makes it possible to assess a country's capacity to transform its financial system in favor of sustainable instruments. On the one hand, this allows for the normalization of observed effects across the sample; on the other, it enables an assessment of the country's debt sustainability, thereby aligning most effectively with the study's objective of analyzing the impact of sustainable financial instruments on ensuring environmental-economic resilience. The second model looks as follows:

$$EERI_{it} = \beta_0 + \beta_1 GreenBondGDP_{it} + \beta_2 NRI_{it-1} + \beta_3 KOFGI_{it-1} + \beta_4 GNIpc_{it} + \beta_5 PolStab_{it} + \beta_6 GovEff_{it} + \varepsilon, \quad (2)$$

where $GreenBondGDP_{it}$ – Green Bond Issuances to the GDR ratio in country i for the period t, %.

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Given that the implementation of sustainable development projects requires a significant time period, a time lag ranging from 0 to 5 years was incorporated into the model to test the hypothesis regarding the delayed impact of sustainable financial instruments on environmental-economic resilience; this lag applies to variables representing the absolute volume of green bond issuance and the share of such issuance in the country's GDP. Furthermore, the Network Readiness Index and KOF Globalisation Index parameters were included in all models with a one-year time lag to account for the long-term effects of digital and globalization-related transformations.

The study employs panel regression modeling. Results from the Hausman and Breusch-Pagan tests confirmed that the random-effects model is the most appropriate specification. Based on the available statistical data for all model parameters, the study covers the period from 2012 to 2025. Stata 14/SE software was used for the calculations.

RESULTS

To analyze current trends in green bond issuance across countries, Figure 1 presents a bubble chart illustrating the relationship between the Network Readiness Index, the KOF Globalization Index, and the volume of green bond issuance (in USD billion) by country.

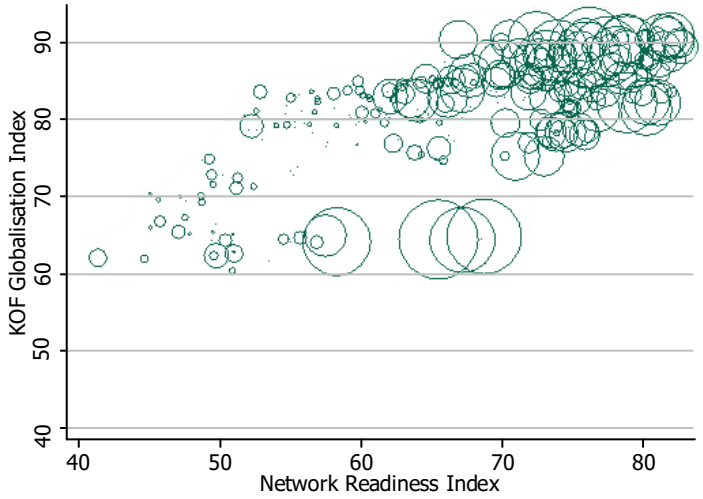


Figure 1. Green bond issuance by countries in terms of their network readiness and globalization level.

Graphical analysis reveals a pronounced positive spatial correlation between a country's level of digital development, its degree of integration into global economic ties, and its activity in the sustainable finance market. The highest concentration of large-volume green bond issuances is observed in the upper-right quadrant. This confirms that highly developed nations, which are characterized by high network readiness and deep integration into global capital markets, are the primary drivers of the green finance market. Notably, significant issuance volumes also appear in the chart's mid-range zone. This cluster corresponds to large emerging economies that, despite moderate levels of overall globalization, possess substantial market potential and actively implement targeted incentives for green investments and digitalization. Conversely, countries with low digitalization and globalization indicators show only sporadic, small-scale issuance-es, pointing to institutional and technological barriers to attracting green capital. These findings confirm the theoretical links between digitalization, globalization, and the use of sustainable financial instruments.

We also present a graphical representation of the key outcome variable: the Environmental-Economic Resilience Index (Figure 2). Visual analysis of the panel data allows us to identify specific key patterns. Indeed, most European Union countries (notably Austria, Finland, France, Germany, and Sweden), as well as Switzerland, the United Kingdom, and the USA, demonstrate a consistently high level of environmental-economic resilience with only minor fluctuations. It is also worth noting the heterogeneity among developing countries, which fall into the lower range of index values. Ukraine is characterized by marked volatility in this indicator. The graph shows a significant decline in 2014–2015, which is driven by macroeconomic and geopolitical shocks. It is followed by a clear positive trend of recovery and rising resilience, indicating high systemic adaptive capacity; however, this capacity diminishes with the onset of the full-scale war.

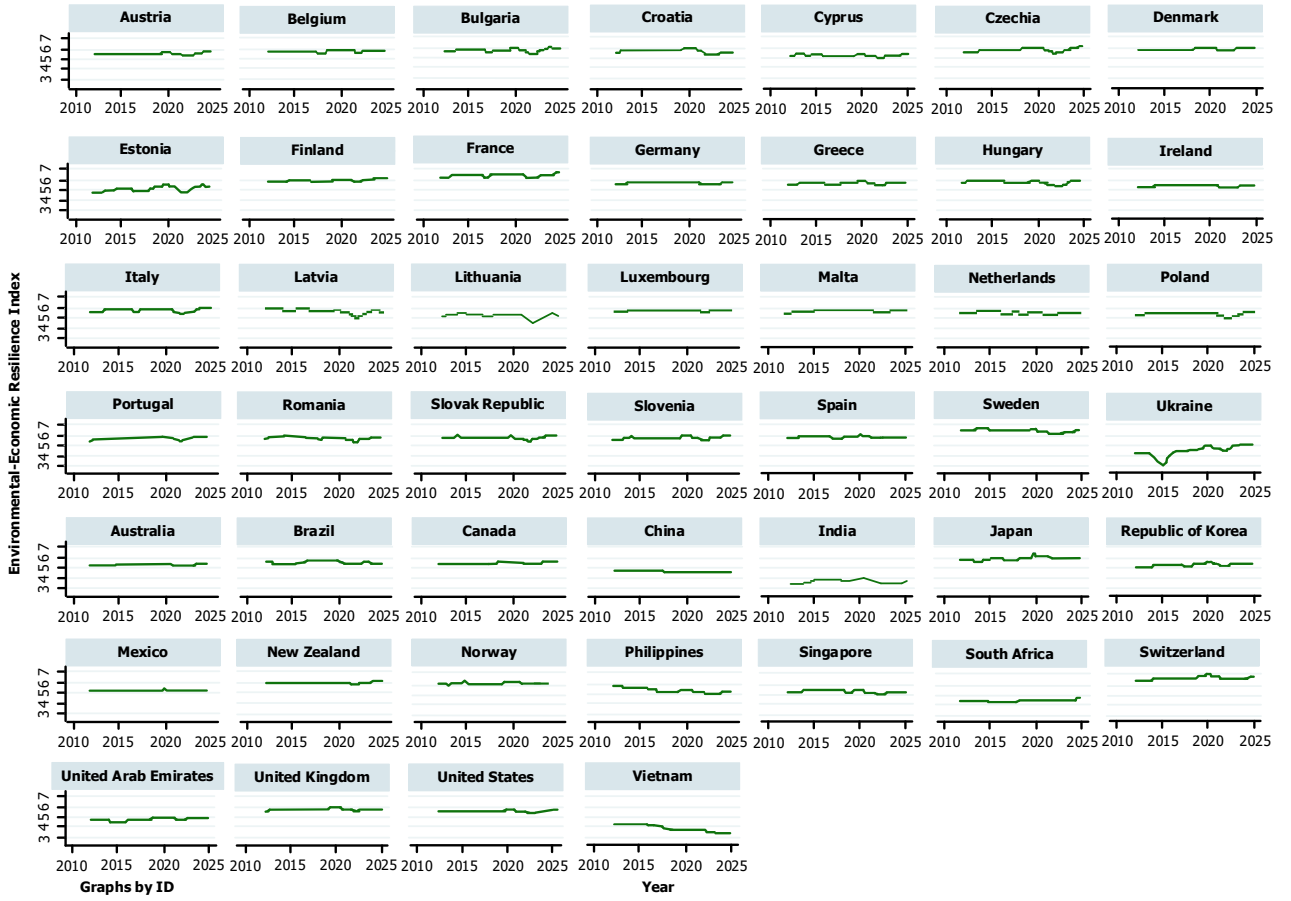


Figure 2. Environmental-economic resilience index by countries for 2012-2025.

Table 1 presents descriptive statistics for all model variables. The averaged data confirm significant heterogeneity among the sampled countries regarding the volume of green bond issuance. Specifically, while the mean value is USD 8.769 billion, the standard deviation is nearly double that figure, indicating that the green bond market is heavily concentrated in a few major leading nations. An analysis of the mean values and dispersion of the green bond-to-GDP ratio confirms that, for most countries, green bonds still represent a negligible share of the economy, with high values observed only in select "green" financial hubs. Conversely, the composite index of environmental-economic resilience exhibits a distribution close to normal, with a low standard deviation. It is also worth noting that the sample of countries shows moderate variation in levels of digital readiness. In contrast, globalization index data indicate that most countries in the sample are highly integrated into the global economy. Gross National Income (GNI) per capita figures reflect a sample characterized by a wide range of socio-economic development levels, while average public governance quality indicators point to predominantly well-developed institutions across the sampled countries.

Table 1. Summary statistics of research variables.

Variables	Obs	Mean	Std. Dev.	Min	Max
GreenBond	369	8.769	15.017	0.004	97.63
GreenBondGDP	369	1.15	2.998	0.000	30.965
EERI	644	5.526	0.529	2.870	7.020
NRI	276	65.688	10.002	41.57	82.75
KOFGI	644	79.247	9.453	44.71	92.84
GNIpc	644	31720.087	22087.112	1317.771	105900
PolStab	644	0.523	0.638	-1.993	1.496
GovEff	644	1.065	0.732	-0.74	2.28

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The construction of economic-mathematical models regarding the impact of the absolute volume of green bond issuance on a country's environmental-economic resilience allowed for the derivation of regression equations demonstrating a sufficient level of adequacy and statistical significance, enabling the results concerning the determined regression coefficients to be summarized in Table 2.

Table 2. Results of modeling the impact of the absolute volume of green bond issuance on the country's environmental-economic resilience. Note: the p-values of regression coefficients are presented in parentheses; *** – indicates statistical significance at the 99% level; ** – 95%; * – 90%.

Variable	Model 1 (lag 0)	Model 2 (lag 1)	Model 3 (lag 2)	Model 4 (lag 3)	Model 5 (lag 4)	Model 6 (lag 5)
GreenBond	-0.001 (0.340)	-0.002** (0.045)	-0.001 (0.418)	0.000 (0.828)	0.002* (0.085)	-0.001 (0.708)
NRI	-0.026*** (0.000)	-0.021*** (0.000)	-0.017*** (0.000)	-0.018*** (0.000)	-0.020*** (0.000)	-0.018*** (0.000)
KOFGI	0.016 (0.234)	-0.012 (0.272)	-0.006 (0.634)	0.003 (0.809)	0.004 (0.703)	0.000 (0.997)
GNIpc	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.001)
PolStab	0.047 (0.637)	-0.107 (0.220)	-0.146* (0.087)	-0.101 (0.278)	-0.024 (0.800)	-0.128 (0.215)
GovEff	0.089 (0.364)	0.051 (0.489)	0.014 (0.841)	0.003 (0.962)	0.125 (0.120)	0.058 (0.448)
Model adequacy criteria						
F	7.08	10.75	8.03	7.02	7.70	6.04
Prob>F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Obs	192	223	212	202	191	174

Calculations based on a model specification characterizing the impact of the absolute volume of green bond issuance on a country's level of eco-economic resilience revealed a time lag before this impact becomes statistically significant. Notably, the overall effect of green bond issuance on ensuring eco-economic resilience varies substantially over time. Specifically, a decline in the level of eco-economic resilience is observed in the year following issuance. This result is consistent with the initial economic costs typical of long-term investment projects. Conversely, a positive aggregate eco-economic effect is achieved only four years after issuance. This indicates that green bonds can serve as an effective tool for eco-economic policy only in the long term. That conclusion is valuable for formulating strategies regarding the use of sustainable financial instruments. An analysis of the control variables included in the model also demonstrates several interesting insights. Examining the drivers of economic digitalization and globalization in terms of their impact on national sustainable development produced rather unexpected results; the level of institutional digitalization, as measured by the Network Readiness Index, proved to be a significant inhibitor of countries' eco-economic resilience. This indicates that the additional environmental costs associated with rising digitalization significantly outweigh the generated economic benefits. On the other hand, the level of globalization did not prove to be an effective determinant of ensuring eco-economic resilience, as the results obtained lack statistical significance. An analysis of public governance efficiency variables revealed that they were not significant determinants of eco-economic resilience; consequently, the hypothesis regarding the role of the institutional environment in ensuring the effective use of green bonds for the country's sustainable development could not be confirmed.

On the other hand, within the context of a strategic analysis regarding the impact of sustainable financial instruments on ensuring the country's environmental and economic resilience, it is also necessary to examine a model in which the primary factor variable is the share of green bond issuance in the country's GDP. Table 3 presents the summarized results of the study.

An analysis of econometric models constructed with varying time lags demonstrated the scale of green bond implementation within the country's financial system. Unlike the absolute volume of issuance, the ratio of green bond issuance to GDP is a significant factor influencing the country's environmental-economic resilience only in the short term. Notably, an increase in the share of green bonds relative to GDP acts as a factor that reduces the country's aggregate level of environmental-economic resilience. The quantified magnitude of this negative impact diminishes when a one-year time lag is introduced into the model. Unfortunately, as the time lag increases, the coefficients associated with the variable factor become statistically insignificant, even though the model's overall goodness-of-fit remains intact. Nevertheless, the sign of

the coefficients suggests a low probability of achieving a positive impact over the longer term. This leads to a crucial strategic conclusion regarding the need for a balanced state policy on the use of sustainable financial instruments. While their application is undoubtedly vital for ensuring national sustainable development and for restoring and preserving the natural environment, the issuance of green bonds must be accompanied by safeguards to mitigate additional economic losses and manage the risks associated with rising debt burdens. These findings are particularly relevant for countries with transition economies, which are characterized by unstable levels of sustainability. Accordingly, the issuance of "green" bonds should take place in relatively small volumes, with a gradual increase to avoid financial shocks.

Table 3. Results of modeling the impact of the share of "green" bond issuance in a country's GDP on its environmental-economic resilience. Note: the p-values of regression coefficients are presented in the parentheses; *** – indicates statistical significance at the 99% level; ** – 95%; * – 90%.

Variable	Model 1 (lag 0)	Model 2 (lag 1)	Model 3 (lag 2)	Model 4 (lag 3)	Model 5 (lag 4)	Model 6 (lag 5)
GreenBondGDP	-0.017** (0.037)	-0.014** (0.035)	-0.006 (0.442)	-0.012 (0.124)	-0.006 (0.560)	-0.019 (0.110)
NRI	-0.028*** (0.000)	-0.024*** (0.000)	-0.018*** (0.000)	-0.021*** (0.000)	-0.021*** (0.000)	-0.020*** (0.000)
KOFGI	0.018*** (0.153)	-0.008 (0.493)	-0.003 (0.828)	0.006 (0.583)	0.001 (0.898)	0.003 (0.777)
GNIpc	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-0.000*** (0.000)	-9.75e-06*** (0.001)	-0.000*** (0.001)
PolStab	0.038 (0.696)	-0.088 (0.301)	-0.141* (0.096)	-0.119 (0.179)	-0.058 (0.534)	-0.126 (0.198)
GovEff	0.093 (0.338)	0.045 (0.530)	0.015 (0.829)	0.016 (0.817)	0.059 (0.421)	0.063 (0.408)
Model adequacy criteria						
F	7.84	10.86	8.02	7.52	7.13	6.56
Prob>F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Obs	192	223	212	202	191	174

The influence of control variables is also significant at this stage of the study. Specifically, the level of network digital readiness, as in the previous model, acts as a factor that can exacerbate losses in eco-economic resilience. At the same time, statistical evidence confirms that an increase in a country's level of globalization can, to some extent, mitigate the negative impact of green bond issuance on its eco-economic resilience. This highlights the considerable potential of leveraging international partnerships for "green" investment projects to maximize environmental benefits while minimizing losses in economic resilience. Conversely, a rise in per capita gross national income also proved to be a factor that intensifies losses in eco-economic resilience. This indicates that economically successful nations must make significant efforts to transform their economic systems in a way that reduces the environmental footprint of their operations.

Synthesizing the empirical findings with the theoretical principles of "green" finance enabled the development of a conceptual model illustrating the operation of sustainable financial instruments in the context of ensuring eco-economic resilience, while accounting for the impact of contemporary globalization and digitalization trends (Figure 3).

Global trends of globalization and digitalization are driving large-scale changes in the development landscape for "green" financial instruments, acting as external catalysts for formalizing their development paths. For instance, the diverse interpretations of the forms and types of "green" finance across different countries, combined with a lack of consensus among issuers, have necessitated a move toward standardization through the creation of internationally recognized taxonomies and compliance standards that align financial instruments with sustainable development goals. These norms and standards provide a foundation for harmonizing the definitions of sustainable financial instruments within national financial legislation. Furthermore, the institutional environment for "green" finance is significantly shaped by the international regulatory framework covering environmental emission limits, the greening and decarbonization of the economy, investor protection, and central bank and tax policies that support sustainable financial instruments. Collectively, these factors shape the national system of rules, norms, and restrictions governing sustainable financial instruments, as well as the incentive measures that complement them. A third manifestation of globalization influencing the development of "green" financial instruments is the cross-border flow of "green" investment capital. Investor requirements and preferences when selecting sustainable development projects are driving a global trend toward the unification of ESG standards to ensure countries remain competitive in attracting investment. Another global trend characterized by rapid scaling is the digitalization of the economy.

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Its impact on the development of sustainable financial instruments manifests in two ways: the emergence of digital "green" instruments and the use of digital technologies for the issuance of financial instruments, capital allocation, data collection, and the verification of compliance with ESG standards. In this context, digitalization acts as a factor that simplifies the processes of issuing and redeeming sustainable financial instruments while simultaneously creating a robust foundation for preventing and minimizing greenwashing.

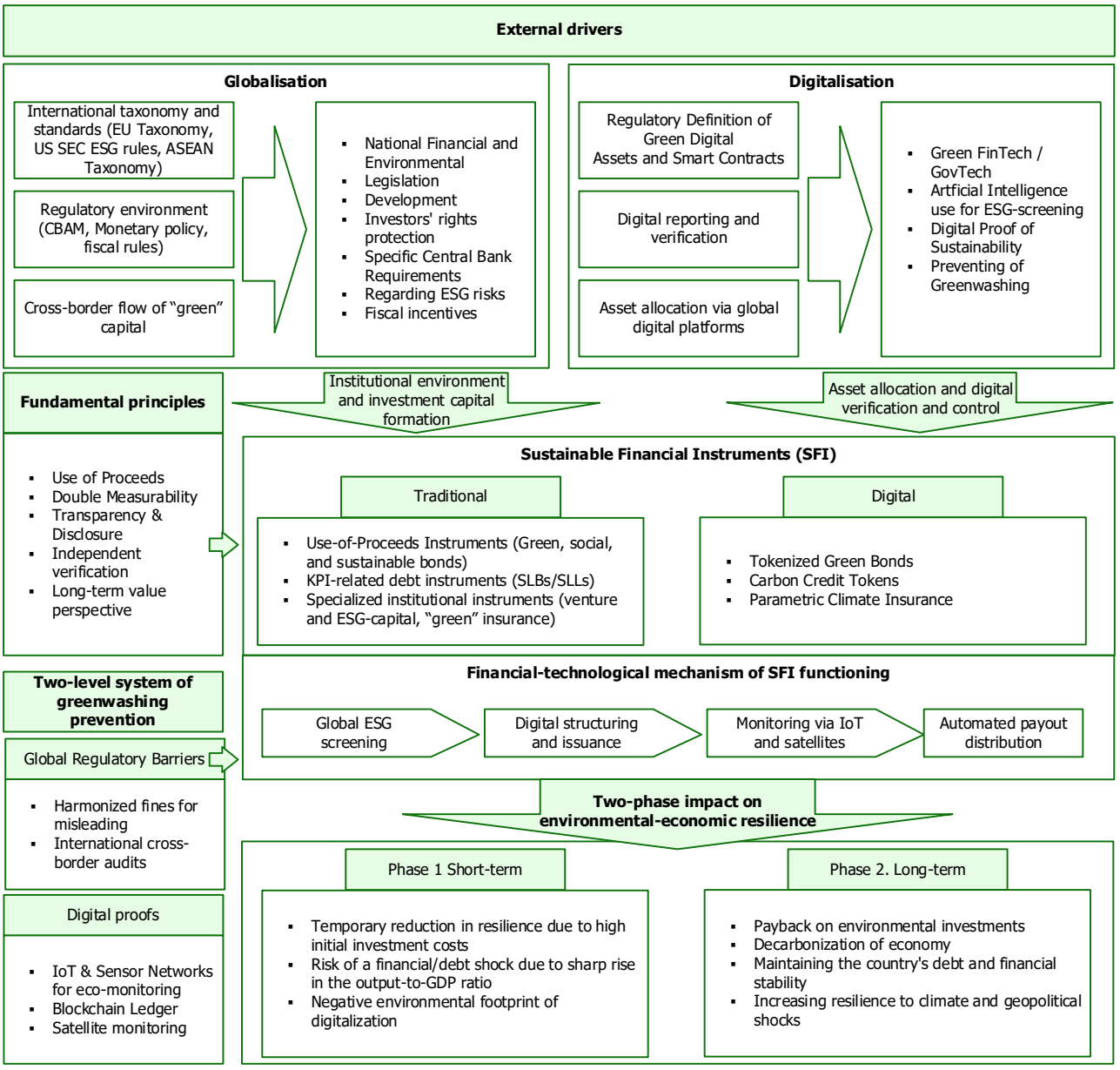


Figure 3. Conceptual model of sustainable financial instruments for ensuring environmental-economic resilience.

To deliver tangible environmental and social benefits, the use of sustainable financial instruments must adhere to several fundamental principles. First, the issuance of sustainable financial instruments requires a clear link between the capital raised and environmentally or socially beneficial projects. As findings by Poggensee (2025) indicate, investor preferences are significantly influenced by a precise definition of the sustainable outcomes targeted by these instruments and the level of confidence that such outcomes will be achieved. Second, the assessment of sustainable financial instruments must address two dimensions: the impact of the environment on the issuer's financial position and the impact of the issuer's activities on the environment and society. Third, adherence to transparency requirements is crucial, entailing full disclosure of ESG information throughout the instrument's entire lifecycle. Fourth, to prevent greenwashing, the assessment of whether sustainable financial instruments meet ESG standards must involve independent third-party verification, which also facilitates global comparability. Fifth, the evaluation of sustainable financial instruments must adopt a long-term perspective, prioritizing long-term value creation over short-term profit.

Global practice regarding the use of sustainable financial instruments has led to their classification into two key groups: traditional and digital. Among traditional instruments, the most common are purpose-specific sustainable bonds, which vary according to their intended use of proceeds. A distinct category comprises KPI-linked instruments, where debt servicing terms (such as the coupon rate) adjust based on the issuer's achievement of specific ESG targets. Specialized institutional instruments such as venture capital funds dedicated to ESG-focused startups are also gaining significant traction. Digital financial instruments involve the integration of digital technologies for the issuance and management of investment capital; examples include fractional green bonds based on blockchain technology.

A crucial aspect of developing the institutional framework for sustainable financial instruments is the establishment of a system to prevent greenwashing. This system must combine regulatory safeguards and international information sharing with the use of objective digital technologies for data collection, verification, and storage. Thus, integrating digital capabilities into the issuance and management of sustainable financial instruments expands the fintech mechanisms underpinning their operation. This entails using artificial intelligence to automatically analyze international news, big data, and corporate reports; allocating assets via global digital platforms using smart contracts; transmitting operational data from investment assets directly to the financial protocol without human intervention; and automating payouts based on actual KPI achievement.

The results of the economic-mathematical modeling demonstrate that the impact of sustainable financial instruments on ensuring eco-economic resilience is two-phased. In the short term, economic resilience declines due to the increased debt burden on the economy required to finance sustainable development investment projects; this effect intensifies in proportion to the rising ratio of sustainable financial instruments to the country's GDP. Furthermore, the negative impact of digitalization exacerbates destructive environmental consequences. Conversely, in the long term, it is possible to partially transform these identified negative effects and derive positive outcomes from the use of sustainable financial instruments. From an environmental perspective, the implementation of sustainable development investment projects leads to a reduced carbon footprint, lower levels of environmental pollution, and accelerated decarbonization and energy transition. Positive long-term consequences are also evident in the economic dimension, driven by the diversification of capital sources, lower resource costs for "green" businesses, reduced transaction costs resulting from the digitalization of issuances, and enhanced resource efficiency and economic competitiveness. Ultimately, this fosters systemic eco-economic resilience, characterized by reduced economic system vulnerability to climate shocks and the transformation of traditional industries based on circular economy principles. However, it should be noted that generating volumes of sustainable financial instruments that are systemically significant for the national economy extends the timeframe for achieving a return-on-investment capital. This necessitates the implementation of safeguards against shocks to eco-economic resilience and requires the national strategy to account for more prolonged periods of reduced eco-economic resilience during the "green" transition.

DISCUSSION

The results indicate that the use of sustainable financial instruments offers limited potential for enhancing eco-economic resilience. Specifically, a positive effect is observed only in the long term and solely regarding the absolute volume of green bond issuance; an increase in the ratio of green bond issuance to national GDP does not lead to improved eco-economic resilience in any of the periods analysed. This suggests that sustainable financial instruments should be employed primarily with a view to achieving societal benefits, while also considering the constraints they may impose on economic growth.

Analysis of these results in the context of achieving positive eco-economic outcomes from green bond issuance is important to consider the heterogeneity of green finance effects. For instance, Bi et al. (2026) found that green bonds do indeed help reduce the relative energy intensity of enterprises. However, these effects are realized only for new energy enterprises located in highly developed cities or cities with a high level of environmental awareness. Corporate characteristics also play a role; notably, private, low-tech small and medium-sized enterprises (SMEs) demonstrate more consistent results. This highlights the need for further research into the key prerequisites for achieving positive impacts through sustainable financial instruments.

The observed inverse impact of digitalization on eco-economic resilience can be compared with the findings of Pham (2026) regarding the differential effects of institutional and digital infrastructure on banking system stability, which are sufficient to ensure competitive equilibrium only in developed economies. Li et al. (2025) empirically confirmed that the development of digital infrastructure significantly increases carbon emissions, thereby substantially undermining the environmental sustainability of the national economy. Furthermore, researchers link the advancement of digitalization and

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artificial intelligence to the escalation of greenwashing risks, including within the realm of green investment projects (Guglyuvatyy, 2026), which underscores the importance of institutional regulation in the market for sustainable financial instruments.

The findings regarding the partially confirmed impact of globalization levels on ensuring eco-economic resilience align, to some extent, with the results obtained by Liang (2026) concerning the U-shaped effect of geopolitical uncertainty on R&D investment by renewable energy companies. This highlights the importance of considering geopolitical factors when developing models for sustainable financial instruments. On the other hand, the observed positive impact of globalization on eco-economic resilience appears somewhat controversial when compared to the destructive impact of globalization and economic openness on the environment identified by Balsalobre-Lorente et al. (2026). However, researchers have also confirmed that financial development can mitigate the negative environmental footprint in the long term. This is fully consistent with the concept of strategically utilizing sustainable financial instruments to ensure long-term eco-economic resilience.

While this study offers robust empirical and theoretical contributions, several limitations should be acknowledged to contextualize the findings:

1. Data Limitations and Sample Coverage. The sample of 46 countries, while globally representative, is skewed toward developed and major emerging market economies due to the historical availability of green bond data. Developing and low-income countries, which are more vulnerable to climate change, remain underrepresented due to underdeveloped local bond markets. Also, given that the market for green bonds matured significantly only after the mid-2010s, early-year data (2000–2010) required interpolation and reliance on proxy variables for certain digital and sustainability metrics.
2. Instrument Specificity. The empirical modeling primarily focused on green bonds as the primary quantitative proxy for sustainable finance. Other rapidly growing instruments, such as sustainable bonds, social bonds, and climate-oriented venture capital, were not included in the econometric models due to data constraints across the full panel.
3. Environmental-economic resilience measurement. Although the construction of the composite index of environmental-economic resilience represents a generalization of environmental and economic features of countries, specific localized environmental and economic trade-offs may be smoothed out during aggregation.
4. Fixed Lag Structure Assumptions. The empirical specification applied uniform lag structures across diverse economies. In reality, the time lag between capital allocation and tangible ecological output varies by asset class.
5. Unobserved Macroeconomic and Geopolitical Shocks. External macro-shocks (such as global financial crises, the COVID-19 pandemic, and major geopolitical conflicts affecting global energy markets) introduce exogenous volatility that may temporarily distort the structural parameters of resilience.

CONCLUSIONS

The study enabled the development of a comprehensive conceptual model regarding the functioning of sustainable financial instruments designed to ensure the eco-economic resilience of national economies amidst digitalization and globalization. It also allowed for the empirical verification of time-lagged effects and the role of institutional and techno-logical prerequisites in realizing this impact.

Regarding Research Objective 1 (RO1), it was demonstrated that the transition from traditional to sustainable finance necessitates shifting from a paradigm of short-term profit orientation to one that prioritizes the long-term assessment of eco-economic well-being. It was determined that sustainable financial instruments (specifically green bonds) operate within a system of complex, non-linear interdependencies, wherein environmental and economic outcomes are not instantaneous but require significant time for the adaptation and implementation of investment projects.

Regarding RO2, an aggregated indicator of eco-economic resilience was constructed using the principal component method, combining 12 balanced, normalized indicators (six economic and six environmental) covering the period 2000–2025. This enabled a comprehensive assessment of the adaptive capacity and resilience of macrosystems across a sample of 46 countries.

The assessment of the short- and long-term impacts of green bond issuance (RO3) empirically demonstrated the two-phase nature of green finance's influence. In the short term (a one-year lag), green bond issuance triggers a tempo-rary decline in resilience levels due to initial capital expenditures and an increased debt burden. In the long term (a four-year

lag), a statistically significant positive effect from the absolute volume of green bond issuance is observed, confirming their effectiveness as a tool for long-term environmental policy. These findings partially confirmed H1 (regarding the long term) and fully confirmed H3 (regarding the delayed nature of the positive impact). Conversely, H2, which posited a more significant impact from the relative level of sustainable financial instruments within GDP, was rejected.

The analysis of the impact of contextual determinants (RO4) revealed that rising digital readiness acts as an inhibitor of eco-economic resilience, as the environmental footprint of digital infrastructure outweighs current economic benefits. This fully rejects H4. Globalization proved to be a factor capable of mitigating short-term shocks resulting from an in-crease in the relative share of green bonds in GDP, which partially confirms H5. At the same time, institutional indica-tors showed no statistically significant direct impact in the constructed models, while rising national wealth emerged as a constraining factor. This only partially confirms H6.

A comprehensive conceptual model for the functioning of sustainable financial instruments (RO5) has been developed, systematizing external drivers (globalization, digitalization), fundamental principles (purpose-driven use, dual measurability, transparency), the financial-technological mechanism (AI, IoT, smart contracts), the two-phase nature of the impact, and a two-level system for preventing greenwashing in the application of these instruments. The proposed model accounts for identified empirical patterns regarding time lags and the differentiated impact of sustainable financial instruments on a country's environmental-economic resilience. Factoring in the time lag reveals that a positive ag-aggregate environmental-economic effect is achieved only in the long term (after four years). In the environmental dimension, this positive effect arises from accelerated decarbonization driven by the global scaling of technologies, a global reduction in the carbon footprint, and the prompt detection and mitigation of environmental damage. In the economic dimension, domestic businesses gain increased access to low-cost global "green" capital, while transaction costs decrease due to the digitalization of issuances and the avoidance of barriers such as the Carbon Border Adjustment Mechanism (CBAM). This ensures the national environmental-economic system's systemic capacity to rapidly adapt to global climate and financial shocks, underpinned by an infrastructure that is transparent, digitized, and integrated into the global landscape. Conversely, the finding that the share of green bonds relative to a country's GDP lacks a positive impact imposes objective limits on the excessive scaling of their issuance, to avoid economic shocks and the loss of national economic resilience. Contrary to conventional views, digitalization acts as a constraint on eco-economic resilience due to the growing environmental footprint of digital infrastructure and the risks of AI-driven greenwashing. This necessitates the integration of specialized environmental safeguards into digital policy. At the same time, it is advisable to focus specifically on leveraging digital technologies to prevent and combat greenwashing. Globalization plays an adaptive role, serving to mitigate short-term financial shocks associated with the introduction of green bonds by enabling risk distribution through the attraction of international capital and technology. To minimize negative short-term shocks, public policy should prioritize a gradual, measured increase in green bond issuance alongside the establishment of an anti-greenwashing monitoring system.

Considering the identified research limitations allows for the determination of priority areas for future scholarly inquiry. First, it is advisable to broaden the scope of research on sustainable financial instruments. This entails incorporating not only green bonds but also social bonds, sustainability-linked bonds, tokenized carbon credits, and green venture capital into empirical models as statistical data becomes available. Second, differentiating research subjects by sector and region is warranted. One possible approach is to conduct cluster analysis distinguishing between transition economies, developed economies, and developing nations, alongside examining microeconomic effects at the sectoral level (e.g., energy, industry, and the agro-industrial complex). Third, there is a pressing need to develop more precise indicators to separately assess the positive impact of Green FinTech (such as optimized monitoring) and the negative environ-mental footprint of digital infrastructure (including data center energy consumption, cryptocurrency mining, and e-waste). Fourth, the identified adverse effects of green bond issuance on eco-economic sustainability highlight the value of employing threshold models and dynamic panel models; these can help determine the precise debt-load limits for green bonds within which short-term financial risks do not jeopardize systemic macroeconomic stability. Fifthly, modeling the impact of exogenous factors (military conflicts, energy crises, restrictive tariff barriers) on the trajectory of restoring ecological-economic resilience is a relevant issue.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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КОНЦЕПТУАЛЬНА МОДЕЛЬ СТАЛИХ ФІНАНСОВИХ ІНСТРУМЕНТІВ ЗАБЕЗПЕЧЕННЯ ЕКОЛОГО-ЕКОНОМІЧНОЇ СТІЙКОСТІ В УМОВАХ ЦИФРОВІЗАЦІЇ ТА ГЛОБАЛІЗАЦІЇ

Ця стаття спрямована на розробку комплексної концептуальної моделі функціонування сталих фінансових інструментів для забезпечення еколого-економічної стійкості національних економік в умовах цифровізації та глобалізації. Вона передбачає емпіричне оцінювання складних відстрочених у часі ефектів випуску зелених облігацій і дослідження пом'якшувальної ролі інституційних, технологічних і соціально-економічних детермінант контексту.

Емпіричні результати показують чіткий двофазний вплив випуску зелених облігацій на макростійкість із затримкою в часі. У короткостроковій перспективі випуск зелених облігацій викликає статистично значуще тимчасове зниження

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еколого-економічної стійкості через початкові витрати на розміщення капіталу та збільшення тягаря обслуговування боргу. У довгостроковій перспективі абсолютний обсяг випуску зелених облігацій має значний позитивний результат, доводячи їхню ефективність для структурного екологічного переходу. І навпаки, збільшення співвідношення зелених облігацій до ВВП спричиняє постійний короткостроковий негативний тиск, підкреслюючи ризики стійкості боргу, якщо він зростає занадто швидко. Крім того, готовність мережі діє як потужний гальмівник стійкості в усіх часових горизонтах, указуючи на те, що негативний екологічний слід цифрової інфраструктури та інтелектуального потенціалу загрожує «зеленим відмиванням». Глобалізація демонструє захисну буферну здатність проти короткострокових боргових шоків, тоді як стандартні інституційні показники не відображають прямої статистичної значущості.

Основним результатом дослідження є розробка багатовимірної концептуальної моделі функціонування стійких фінансових інструментів. Він поєднує в собі цифрові технології та дворівневу систему для запобігання «зеленому відмиванню» з метою трансформації сталого фінансування в макроекономічну стійкість. З огляду на те, що емпіричний аналіз продемонстрував існування часового лагу та короткострокових ризиків надлишкової заборгованості, рекомендації для державної політики полягають у системному переході від агресивного збільшення обсягів до зваженого, регульованого випуску зелених облігацій. Державна стратегія має поєднувати суворий цифровий моніторинг цільового використання коштів, залучених за допомогою сталих фінансових інструментів, із розробкою екологічних запобіжників для цифрової інфраструктури, таким чином мінімізуючи фінансові шоки та забезпечую-чи довгострокове зростання еколого-економічної стійкості.

Ключові слова: сталі фінанси, зелені облігації, еколого-економічна стійкість, цифровізація, глобалізація, концептуальна модель, макроекономічна стабільність, фінансові інструменти, трансформації, сталий розвиток

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