Research Article

Insurance Industry Development and Progress Toward the Sustainable Development Goals: A Cross-Country Empirical Analysis

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Abstract

Accelerating climate change has intensified economic losses from natural disasters and heightened the demand for effective financial risk-management mechanisms worldwide. In this context, the insurance industry has emerged as a critical component of sustainable development by enhancing financial resilience, supporting social protection systems, and facilitating climate adaptation. This study empirically examines the relationship between insurance industry development and progress toward the Sustainable Development Goals (SDGs) using cross-country data from 155 countries. Insurance penetration, measured as the ratio of total insurance premiums to gross domestic product, is employed as a proxy for insurance industry depth, while sustainable development performance is captured using the SDG Index. A log–log regression framework is applied to assess the magnitude and statistical significance of the association between insurance penetration and SDG outcomes. The results reveal a positive and highly significant relationship, indicating that higher insurance penetration is associated with improved SDG performance across countries The model explains 34.1% of the cross-country variation in SDG Index scores ($R^2 = 0.341$), indicating a substantial association between insurance penetration and sustainable development outcomes. To further explore potential non-linearities, an Artificial Neural Network model is applied, identifying a threshold level of insurance penetration below which SDG performance remains constrained. These findings highlight insurance development as an important policy instrument for advancing the SDGs, particularly in climate-vulnerable and emerging economies where insurance markets remain underdeveloped such as Mongolia.

Keywords

Sustainable Development Goals, Insurance Penetration, Sustainable Finance, Climate Risk, Financial Resilience.

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Introduction

Climate change has accelerated sharply over the past century, with profound implications for ecosystems and human systems worldwide. Since the 19th century, the average global temperature has risen by approximately 1.55°C, largely attributed to anthropogenic greenhouse gas emissions (World Meteorological Organization, 2024). While this warming represents an already critical threat, its pace poses further challenges for adaptation and risk management.

Mongolia is particularly vulnerable, as its average annual temperature has risen by about 2.25°C over the past 80 years, which is more than double the global average. According to adaptation reports, the rising temperature has coincided with fading cold days (a decline of roughly 15 days over 45 years) and an increase in hot days by about 24 days. Between 1996 and 2010, the country recorded an average of about 2,400 natural hazard events each year, but this figure increased to nearly 4,300 after 2010, which shows how rapidly climate risks have escalated (Davaajargal et al., 2023).

These escalating climate risks drive growing demand for financial protection. As households, businesses, and institutions face heightened exposure, the insurance industry is emerging as a critical tool for resilience (Development Bank, 2024). Through underwriting, investment, and risk-sharing mechanisms, insurers can help absorb climate-related shocks. However, to fulfil this potential, the insurance industry must innovate by developing climate-sensitive products, aligning with international sustainability standards, and scaling its operations to respond to the expanding risk landscape (Victoria Saporta, 2021).

At the same time, the global shift toward sustainable development underscores the strategic role of financial sectors. The transition from short-term profit models toward long-term value creation (LTVC) reflects a broader realignment: sustainability now shapes business strategy. In this context, the insurance industry is uniquely positioned to contribute not only by managing climate risk, but also by financing sustainable infrastructure and supporting social protection systems that align with the Sustainable Development Goals (SDGs) (Vázquez et al., 2025).

Despite the growing recognition of insurance as a key mechanism for managing climate-related and socioeconomic risks, empirical evidence quantifying the relationship between insurance industry development and sustainable development outcomes remains limited (Victoria Saporta, 2021). Existing studies largely focus on qualitative assessments of sustainability frameworks, environmental, social, and governance (ESG) integration, or case-based analyses of specific insurance products. Cross-country empirical research examining how insurance penetration relates to overall progress toward the Sustainable Development Goals (SDGs) is still relatively scarce, particularly for developing and transitioning economies where climate vulnerability is high and insurance industry remains underdeveloped (Development Bank, 2024).

This study seeks to address this gap by empirically investigating the association between insurance industry depth and sustainable development performance using a cross-country dataset covering 155 countries. Insurance penetration, measured as the ratio of total insurance premiums to gross domestic product, is employed as a proxy for insurance market development, while sustainable development outcomes are captured using the SDG Index. By applying a log–log regression framework, the analysis estimates the magnitude and statistical significance of the relationship between insurance penetration and SDG performance. In doing so, the study contributes to the growing literature on sustainable finance by providing quantitative evidence on the role of insurance industry in supporting economic, social, and environmental development.

Beyond its empirical contribution, this research offers important policy insights for climate-vulnerable and emerging economies, with particular relevance for Mongolia. Despite experiencing climate warming at more than twice the global average and facing increasing losses from natural disasters, Mongolia's insurance penetration remains significantly below the global average (Mogge & Kraehnert, 2025). Understanding the potential contribution of insurance industry development to sustainable development outcomes is therefore critical for informing national strategies related to financial resilience, climate adaptation, and long-term development planning.

The paper is organized into six sections. Following this introduction, Section 2 reviews the relevant theoretical and empirical literature on sustainable development and the insurance industry. Section 3 explains the data sources, variables, and econometric methodology. The empirical findings are presented in Section 4 and discussed in Section 5 in relation to sustainable development and insurance policy.

Literature Review

Insurance and Sustainable Development: Theoretical Perspectives

The concept of sustainable development emphasizes the integration of economic growth, social inclusion, and environmental protection in a manner that meets present needs without compromising the ability of future generations to meet their own. Within this framework, financial systems play a critical enabling role by mobilizing resources, managing risk, and supporting long-term investment. Among financial institutions, the insurance industry occupies a particularly important position due to its dual role as both a risk-transfer mechanism and a long-term institutional investor (Inquiry, 2015).

From a theoretical perspective, insurance contributes to sustainable development through several related mechanisms. First, risk pooling and risk transfer reduces income volatility for households and firms, encouraging productive investment and entrepreneurship. In this way, insurance supports economic stability and social welfare, which are essential components of sustainable development. Second, insurance strengthens financial inclusion by providing protection against health shocks, natural disasters, and other risks that disproportionately affect lower-income and vulnerable populations. A further, and increasingly significant, contribution arises from the long-term

nature of insurers' liabilities (Ulrich Grober, 2007). Because insurers manage long-duration obligations, they are well positioned to invest in infrastructure and other long-horizon assets, including those aligned with environmental sustainability and climate resilience. This investment profile allows insurers to support long-term value creation rather than focusing solely on short-term financial returns, linking financial performance with wider societal objectives (Schoenmaker, 2019).

These theoretical insights help explain the growing recognition of insurance as a central pillar of sustainable finance. International initiatives such as the United Nations Environment Programme Finance Initiative (UNEP FI) and the Principles for Sustainable Insurance (PSI) emphasize the integration of environmental, social, and governance (ESG) considerations into underwriting, investment, and risk management practices (Inquiry, 2015). Collectively, these frameworks frame insurance not simply as a financial intermediary, but as a strategic actor capable of influencing development pathways and shaping wider social and environmental outcomes.

Insurance, Climate Risk, and Environmental Sustainability

Climate change has intensified both the scale and frequency of natural disasters, leading to rising economic losses and heightened development risks across countries(Giddings et al., 2002). In this context, the insurance industry plays an important role in managing these climate-related risks by spreading losses across policyholders and over time. This function helps reduce the fiscal pressure on governments and limits the risks of households falling into poverty following climate-related shocks. As a result, insurance has become an increasingly central component of climate adaptation and disaster risk reduction strategies (D'Amato et al., 2024).

The literature highlights a structural shift within the insurance industry moving from a primarily reactive focus on post-disaster compensation toward proactive risk prevention and sustainability-oriented practices (Pfeifer & Langen, 2021). Early forms of environmental liability insurance emerged in response to regulatory requirements following industrial pollution incidents. Over time, insurers expanded their role by introducing green insurance products, parametric insurance instruments, and index-based coverage aimed at managing climate-related risks more efficiently. These innovations reflect a broader effort to integrate climate risk assessment, ESG considerations, and long-term sustainability objectives into core insurance practices (Hall & Walsh, 2025).

Empirical and policy-oriented studies further suggest that the insurance industry influences environmental sustainability not only through claims payments, but also through underwriting standards and investment decisions (Horvey et al., 2024). By pricing risk more accurately and limiting coverage for environmentally harmful activities, insurers can discourage carbon-intensive behavior while encouraging investment in renewable energy and climate-resilient infrastructure. In this way, the risk-based pricing mechanism

aligns private incentives with public sustainability goals and reinforces the relevance of the insurance industry to climate action (Holliday et al., 2021).

Insurance and Sustainable Development Goals

Although the insurance industry is explicitly mentioned in only one Sustainable Development Goal, SDG Target 8.10, which emphasizes expanded access to insurance and financial services, its potential contribution extends across multiple goals. Existing studies demonstrate that insurance mechanisms are closely linked to poverty reduction, health coverage, climate resilience, and sustainable urban development (Tešić, 2023). Health insurance supports universal health coverage and financial risk protection, while agricultural and disaster insurance reduce vulnerability among rural and climate-exposed populations (Holliday et al., 2021).

International organizations such as the World Bank, OECD, and the Geneva Association emphasize that the insurance industry strengthens social protection systems and enhances countries' capacity to absorb shocks (Holliday et al., 2021). These institutions argue that insurance contributes indirectly to SDGs related to inequality reduction, economic growth, and institutional resilience by stabilizing income flows and reducing uncertainty. The integration of insurance into public-private partnerships and national development strategies further amplifies its developmental impact (Di Tommaso et al., 2025).

Despite these recognized contributions, much of the existing literature remains qualitative or policy-driven (Pranugrahaning et al., 2023). While descriptive analyses provide valuable insights into institutional frameworks and best practices, they often lack empirical quantification of insurance's contribution to comprehensive sustainable development outcomes. This limitation highlights the need for quantitative analyses that assess how insurance industry development relates to multidimensional measures of sustainability.

Empirical Evidence on Insurance Penetration and Development Outcomes

A growing body of empirical research investigates the relationship between insurance industry development and economic or sustainability-related outcomes. Studies examining insurance penetration, a major indicator of insurance industry depth, generally report positive associations with economic growth, financial stability, and social welfare indicators (Tešić, 2023). Insurance penetration has been linked to reduced output volatility, improved capital accumulation, and enhanced resilience to economic shocks.

Recent studies have begun to explore insurance within the broader sustainable finance framework. Hu et al. (2023) find that green insurance policies significantly promote green innovation in China, highlighting the role of insurance incentives in environmental performance. Sylos Labini et al. (2025) demonstrate that sustainability-oriented insurance strategies are positively associated with financial performance, suggesting alignment between profitability and sustainability objectives. Allianz Research (2025) reports a

positive correlation between insurance penetration and SDG performance, indicating a virtuous cycle between insurance development and sustainability outcomes.

However, existing empirical studies exhibit several limitations. Many focus on single countries or specific sustainability dimensions rather than comprehensive development measures. Others rely on short-term horizons or sector-specific indicators, limiting the generalizability of their findings. Cross-country analyses linking insurance penetration to multidimensional SDG outcomes remain relatively scarce, particularly for emerging and transitioning economies.

Research Gaps and Contribution of the Present Study

Despite the expanding literature on sustainable insurance and climate risk, several important gaps remain. First, there is limited cross-country empirical evidence quantifying the relationship between insurance penetration and overall progress toward achieving the Sustainable Development Goals. Second, existing studies often focus on advanced economies, providing less insight into climate-vulnerable and emerging countries where insurance markets remain underdeveloped. Third, few studies employ comprehensive sustainability indicators, such as the SDG Index, to capture the multidimensional nature of development.

This study addresses these gaps by providing a cross-country empirical analysis of the relationship between insurance market development and sustainable development outcomes using data from 155 countries. By employing insurance penetration as a proxy for insurance market depth and the SDG Index as a comprehensive measure of sustainability, the study contributes quantitative evidence to the sustainable finance literature. Furthermore, by highlighting the implications for Mongolia, the research offers policy-relevant insights for emerging economies seeking to strengthen financial resilience and advance sustainable development.

Research Methodology

Research Design and Approach

This study adopts a quantitative, cross-country research design to empirically examine the relationship between insurance industry development and sustainable development outcomes. The analysis is grounded in the sustainable finance and development economics literature, which increasingly recognizes the insurance industry as key institutions for risk sharing, financial resilience, and long-term economic stability. A cross-sectional econometric approach is employed to identify whether countries with deeper insurance industries exhibit systematically higher levels of progress toward the Sustainable Development Goals (SDGs).

The research design combines descriptive statistical analysis with regression modeling to assess both the direction and magnitude of the relationship between insurance penetration and sustainable development performance. While the analysis is global in

scope, the findings are interpreted with particular attention to emerging and climate-vulnerable economies, including Mongolia, where the insurance industry remain underdeveloped despite rising climate risks.

In addition, an artificial neural network (ANN) model is applied to explore potential non-linear patterns and threshold effects in the relationship between insurance penetration and SDG performance.

Data Sources

The empirical analysis is based on a cross-country dataset covering 155 countries, using the most recent data available for 2024.

Sustainable Development Performance: Data on sustainable development outcomes are obtained from the SDG Index, developed by the Sustainable Development Solutions Network (SDSN) in collaboration with the United Nations. The SDG Index provides a composite score ranging from 0 to 100, reflecting each country's overall progress toward achieving the 17 SDGs. Higher values indicate stronger performance across economic, social, and environmental dimensions. The use of the SDG Index allows for a holistic assessment of sustainable development rather than focusing on a single development dimension.

Insurance Industry Development: Insurance industry development is measured using insurance penetration, defined as the ratio of total insurance gross premiums to gross domestic product (GDP). Insurance premium data are collected from national financial regulatory reports and international insurance databases, while GDP data are obtained from internationally harmonized economic statistics. Higher insurance penetration suggests greater access to risk-transfer mechanisms and stronger financial protection for households and firms.

In our regression analysis dependent variable is the SDG Index score and independent variable is insurance penetration. All variables are harmonized to ensure cross-country comparability. Countries with missing or inconsistent data are excluded from the analysis to ensure statistical validity. To reduce skewness and allow for elasticity interpretation, both the SDG Index and insurance penetration variables are transformed using natural logarithms.

Table 1. SDG Index and Insurance Penetration rate by countries

Country	SDG	InPen	Country	SDG	InPen	Country	SDG	InPen	Country	SDG	InPen
Albania	75.03	1.02%	Czechia	81.26	2.90%	Kyrgyz Republic	74.19	0.25%	Portugal	80.22	4.60%
Algeria	70.47	0.68%	Denmark	85	10.90%	Lao PDR	62.95	0.41%	Qatar	64.93	0.80%
Angola	51.93	0.60%	Djibouti	51.68	0.89%	Latvia	80.99	2.56%	Romania	76.7	1.60%
Argentina	74.4	3.20%	Dominican Republic	73.12	1.60%	Lebanon	63.89	0.20%	Russian Federation	73.1	2.30%
Armenia	74.09	1.60%	Ecuador	70.14	1.80%	Lesotho	55.54	4.03%	Rwanda	60.87	0.59%
Australia	76.88	5.70%	Egypt, Arab Rep.	69.15	0.70%	Lithuania	78.12	1.66%	Saudi Arabia	64.91	2.38%
Austria	82.55	4.30%	El Salvador	68.61	2.10%	Luxembourg	76.81	1.90%	Senegal	63.39	1.44%
Azerbaijan	72.2	0.84%	Estonia	80.46	2.30%	Madagascar	51.22	0.52%	Serbia	77.03	1.90%
Bahamas	63.73	3.03%	Eswatini	57.76	1.89%	Malawi	56.75	0.77%	Sierra Leone	58.19	0.37%
Bahrain	63.56	2.60%	Ethiopia	55.24	0.30%	Malaysia	69.32	4.30%	Singapore	71.41	9.20%
Bangladesh	64.35	0.50%	Fiji	72.29	3.50%	Maldives	70.93	1.50%	Slovak Republic	79.35	2.45%
Barbados	69.19	2.70%	Finland	86.35	10.00%	Mali	56.81	0.60%	Slovenia	81.34	4.70%
Belarus	78.6	1.00%	France	82.76	8.70%	Malta	76.95	3.90%	South Africa	63.44	9.40%
Belgium	80.04	5.50%	Gabon	64.88	2.00%	Mauritania	58.17	0.24%	Spain	80.7	4.90%
Belize	65.55	2.29%	Gambia	57.61	0.44%	Mauritius	70.45	5.70%	Sri Lanka	67.43	0.80%
Benin	56.77	0.69%	Georgia	74.91	1.20%	Mexico	69.28	2.40%	Sudan	49.91	0.48%
Bhutan	72.52	1.20%	Germany	83.45	5.90%	Moldova	78.81	1.00%	Sweden	85.7	9.30%
Bolivia	68.08	1.41%	Ghana	63.05	1.00%	Mongolia	66.31	0.60%	Switzerland	79.3	6.90%
Bosnia and Herzegovina	73.99	1.20%	Greece	78.71	2.40%	Montenegro	73.05	1.74%	Tajikistan	68.09	0.50%
Botswana	63.44	3.27%	Guinea	56.42	0.22%	Morocco	70.85	3.90%	Tanzania	58.2	0.70%
Brazil	73.78	6.00%	Guinea-Bissau	51.86	0.14%	Mozambique	54.35	1.05%	Thailand	74.67	5.69%
Brunei Darussalam	67.04	16.50%	Guyana	66.73	2.74%	Myanmar	62.82	0.10%	Togo	58.37	11.90%
Bulgaria	75.54	2.20%	Honduras	62	2.00%	Namibia	66.54	7.86%	Trinidad and Tobago	61.83	3.00%
Burkina Faso	52.92	1.14%	Hungary	79.53	2.10%	Nepal	67.07	3.30%	Tunisia	72.53	2.46%
Burundi	56.08	1.00%	Iceland	79.54	24.60%	Netherlands	79.21	8.50%	Türkiye	70.47	1.50%
Cabo Verde	68.21	1.56%	India	63.99	3.70%	New Zealand	78.81	3.80%	Turkmenistan	67.13	0.20%
Cambodia	64.9	1.16%	Indonesia	69.43	2.64%	Nicaragua	64.66	2.00%	Uganda	56.13	0.87%
Cameroon	57.28	0.92%	Iran, Islamic Rep.	68.96	2.30%	Niger	49.86	0.34%	Ukraine	74.81	0.80%
Canada	78.83	6.51%	Iraq	64.18	1.00%	Nigeria	54.58	0.34%	United Arab Emirates	70.52	2.90%
Chile	77.82	4.70%	Ireland	78.72	5.20%	North Macedonia	73.8	1.80%	United Kingdom	82.16	10.50%
China	70.85	3.90%	Israel	73.53	5.30%	Norway	82.23	4.00%	United States	74.43	5.70%
Colombia	70.3	3.20%	Italy	79.29	8.00%	Oman	66.11	1.23%	Uruguay	77.09	2.80%
Congo, Dem. Rep.	48.71	0.31%	Jamaica	69.51	2.15%	Pakistan	57.02	0.79%	Uzbekistan	69.24	0.10%
Congo, Rep.	52.7	0.31%	Japan	79.87	8.20%	Panama	69.09	2.10%	Venezuela, RB	62.46	1.50%
Costa Rica	72.88	1.10%	Jordan	69.06	2.50%	Papua New Guinea	51.99	2.00%	Vietnam	73.32	2.30%
Cote d'Ivoire	62.72	0.10%	Kazakhstan	71.11	0.80%	Paraguay	68.02	1.00%	Yemen, Rep.	46.87	0.37%
Croatia	82.19	2.60%	Kenya	62.17	2.40%	Peru	71.88	2.05%	Zambia	54.44	1.10%
Uba	76.74	0.63%	Korea, Rep.	77.33	10.30%	Philippines	67.47	1.60%	Zimbabwe	57.76	1.46%
Cyprus	72.92	3.80%	Kuwait	63.76	0.90%	Poland	81.69	2.20%			

Regression Model

Our regression model was informed by previous research studies, including Allianz's Insuring the Future report (Allianz Research, 2025), which examined the relationship between life insurance penetration and the SDG Index (r = 0.3, p = 0.061), as well as the association between property and liability insurance penetration and the SDG Index (r = 0.62, p < 0.001). The results of the current study indicate that a 1% increase in insurance penetration is associated, on average, with a 5.8 point increase in a country's SDG Index.

Therefore, to examine the relationship between insurance industry development and sustainable development outcomes, a log–log regression model is specified as follows:

$$Ln(SDG) = B_0 + B_1 ln(InsPenet) + e$$

The log–log specification is adopted for several reasons. First, it allows the estimated coefficients to be interpreted as elasticities, indicating the percentage change in sustainable development outcomes associated with a percentage change in insurance penetration. Second, logarithmic transformation reduces the influence of extreme values and improves the linearity of the relationship between the variables. Third, this specification is consistent with previous empirical studies examining the relationship between financial development and sustainability outcomes.

Results

The descriptive statistics and correlation results (Tables 2 and 3) suggest a moderate positive relationship between insurance penetration and the SDG Index. This indicates that higher insurance penetration is generally associated with higher SDG performance, or vice versa.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
SDG	155	68.77568	9.246314	46.87	86.35
InsPenet	155	0.02925	0.0331	0.001	0.246

Source: Authors' calculation

Table 3. Correlation matrix

	InsPenet	SDG
InsPenet	1.0000	
SDG	0.4437	1.0000

Source: Authors' calculation

The results of the log-log regression model indicate that the coefficient for ln (InsPenet) is 0.0749 (p < 0.001), demonstrating a highly statistically significant positive relationship. In practical terms, a 1% increase in insurance penetration is associated with an average 7.4 point increase in the SDG Index. The model explains approximately 34.13% of the

variation in SDG Index values (R^2 = 0.3413; Adjusted R^2 = 0.3370), indicating that insurance penetration alone accounts for a substantial portion of SDG performance differences across countries. Moreover, the overall model is statistically significant (F (1,153) = 79.27, p < 0.001), confirming that the regression provides a meaningful explanation of the relationship between insurance penetration and sustainable development outcomes.

Table 4. Result of log-log regression analysis

Source	SS	df	MS	Number of obs	=	155
Model	1.024715	1	1.025472	F (1, 153)	=	79.27
Residual	1.972715	153	0.012936	Prob > F	=	0
Total	3.004743	154	0.019511	R-squared	=	0.3413
				Adj R-squared	=	0.337
ln_SDG	Coefficient	Std. err.	t	P>| t |	[95% conf.	interval]
ln_InsPenet	0.074986	0.008422	8.9	0	0.058348	0.091625
_cons	4.525394	0.035343	128.04	0	4.455571	4.595217

Source: Authors' calculation

The log-log regression analysis demonstrates a positive and statistically significant relationship between insurance penetration and the SDG Index. Although insurance alone cannot fully explain all variations in the SDG Index ($R^2 \approx 34\%$), it highlights the important role of the insurance industry in enhancing financial accessibility, healthcare, and social protection systems. Therefore, the development of the insurance industry may serve as a key policy instrument for supporting the achievement of the SDGs.

Figure 1 illustrates a positive association between insurance penetration and progress toward the SDGs. Countries with higher levels of insurance penetration tend to achieve stronger SDG performance, while those with more limited insurance coverage generally show lower levels of advancement. This visual evidence reinforces the empirical findings by highlighting the role of insurance industry development in supporting broader sustainable development outcomes.

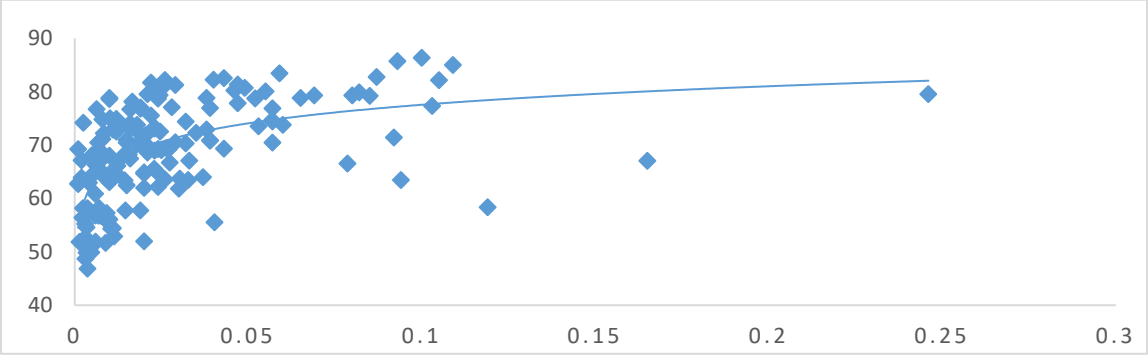

Figure 1. SDG Index and insurance penetration by countries, 2024
Source: Authors' calculation

Artificial Neural Network (ANN) Model

Ongoing research increasingly explores the application of artificial intelligence–based techniques to predict Sustainable Development Goal (SDG) indices. For example, recent studies (Mirghaderi, 2020, 2023) have employed machine learning and deep learning models to capture complex, non-linear relationships among economic, social, and environmental indicators, thereby enhancing the accuracy and robustness of SDG performance forecasting.

Table 5 indicates that the highest SDG Index among the 155 countries is 86. Consistent with the logarithmic scatter plot presented in Figure 1, the SDG performance tends to decline as insurance penetration decreases. While this pattern suggests a potential constraint at lower levels of insurance penetration, no distinct threshold or cut-off point is visually evident. To address this limitation, this section applies an Artificial Neural Network (ANN) model to explore whether a meaningful threshold in SDG performance can be identified.

For this purpose, the SDG Index values reported in the descriptive statistics (Table 2) were converted into a binary outcome variable. Countries with SDG Index values below the sample mean of 68.77 were classified as 0, while those with values above the mean were classified as 1. This transformation resulted in a relatively balanced distribution between the two classes, with proportions of 51% and 49%, respectively.

The ANN model was trained using a multilayer architecture comprising 32, 16, 8, and 1 node. Model training was conducted over 100 epochs with a batch size of 32 and a learning rate of 0.0001. The binary cross-entropy loss function was applied, with ReLU activation functions in the hidden layers and a sigmoid activation function in the output layer. To reduce the risk of overfitting, early stopping based on validation loss was implemented.

The model evaluation produced the following performance metrics. Accuracy = 0.76, F1-score = 0.70, and LIME results, as summarized in Table 5.

Table 5. ANN lime evaluation result

Class 0	Class 1
0 < Insurance penetration <= 0.02	0.02 < Insurance penetration

Source: Authors' calculation

The results of this analysis indicate that countries with an insurance penetration rate below 0.02 tend to exhibit relatively low SDG index scores. In contrast, countries with insurance penetration rates exceeding 0.02 generally demonstrate higher levels of SDG performance.

Discussion and Conclusion

This research examined how the concept of sustainable development, which is the focus of global attention, is affecting the insurance industry, and to identify future development trends, participation, responsibilities, and opportunities in the insurance industry. The findings indicate that insurance companies are increasingly moving beyond their traditional role as risk bearers and are becoming active contributors to environmental sustainability and climate resilience.

One key finding is the shift in underwriting and financing practices, whereby insurers are limiting or refusing coverage for activities with significant environmental impacts, such as coal-fired power generation and highly polluting extractive industries. This change reflects the integration of environmental, social, and governance considerations into insurance decision-making and aligns with broader corporate social responsibility commitments. Through such practices, insurers can influence investment behavior and contribute to the transition toward lower-carbon economic activities.

The results also highlight that sustainability efforts within the insurance industry increasingly extend to insurers' own operations. Many insurance companies have begun to measure and reduce greenhouse gas emissions generated by their internal activities, signaling a commitment to net-zero objectives. This internal alignment strengthens the credibility of insurers' sustainability commitments and reinforces the role of insurance as a responsible institutional actor. For Mongolian insurance companies, aligning operational and strategic policies with international sustainability standards represents an important opportunity to enhance institutional capacity and global competitiveness.

In addition, the expansion of green insurance products illustrates how insurers are using market-based instruments to support environmentally friendly activities. By offering preferential terms for low-emission technologies and sustainable projects, insurance companies can reduce financial barriers to green investment while simultaneously managing climate-related risks. Continued innovation in green insurance products is therefore likely to play a central role in strengthening the insurance sector's contribution to sustainable development.

The findings further confirm that climate change is intensifying the frequency and severity of natural disasters, resulting in rising economic losses. In response, there is growing recognition at both policy and societal levels that investing in insurance reserves and risk management mechanisms represents a forward-looking approach to minimizing future losses. This shift underscores the importance of insurance as a preventive tool rather than solely a post-disaster compensation mechanism.

Overall, the study suggests that the insurance industry is undergoing a structural transformation, assuming a proactive role in risk prevention and sustainability promotion. Regulatory authorities have an important role in supporting this transition by providing clear guidance and incentives that encourage insurers to support environmentally and socially responsible activities through their policies and products. For emerging and climate-vulnerable economies, including Mongolia, strengthening the regulatory and institutional environment for sustainable insurance can enhance financial resilience and support long-term development objectives.

In conclusion, the insurance industry has the potential to serve as a critical link between financial stability, climate adaptation, and sustainable development. By integrating sustainability principles into underwriting, investment, and operational practices, insurers can contribute not only to risk transfer but also to risk reduction and long-term resilience. The continued evolution of the insurance sector toward sustainability-oriented practices will be essential for achieving balanced economic, social, and environmental outcomes in the face of growing climate-related challenges.

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