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Climate-Driven Risks in Tuna Fishing in Indonesia: A Financial Distress Likelihood

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ABSTRACT

The purpose of this research is to investigate how climate change is influencing the risks within the tuna fishing sector in Indonesia. Changes in the environment, like increasing sea temperatures and shifting ocean currents, have impacted the movement and migration patterns of tuna, directly impacting the industry sustainability. The significance of this study lies in the pressing necessity to comprehend the ways in which climate change is impacting the risks encountered by businesses operating in the tuna fishing industry. This research aims to assess the risks that tuna fishing businesses encounter as a result of climate change and to determine how they affect the company's stock value. To conduct this research, a panel data evaluation approach was employed using seven publicly traded companies engaged in the tuna industry as sample subjects. The data used was sourced from company filings with the Indonesia Stock Exchange and capital market figures from the Financial Services Authority (OJK). The research utilizes an Altman Z Score model to evaluate the financial health and risk of bankruptcy of a company by incorporating dummy variables associated with increasing sea temperatures into its analysis. This study aims to offer policymakers evidence-based guidance regarding the consequences of different management strategies for addressing climate fluctuations. Furthermore, the research underscores the significance of taking factors into account when managing financial risks, especially in ensuring the long-term viability of the tuna fishing sector. The uniqueness of this study is found in its approach of merging financial risk analysis with risk assessment methods by utilizing a model that integrates both biological and economic elements to offer a holistic framework for decision-making within the sustainable fisheries sector.

Keywords: Climate Risks; Tuna Fishing; Sea Temperatures; Financial Risks; Stock Price

INTRODUCTION
Background Research

In recent years, climate change has become an increasingly pressing issue in various sectors, including tuna fisheries. Environmental factors, such as rising ocean temperatures, changes in current patterns, and seawater acidity, can alter marine ecosystems and significantly affect tuna populations. Based on data from the International Monetary Fund (IMF) through Jason3 satellite observations, the sea level in Indonesia has increased by 62.3 millimetres (mm) as of quarter 1 of 2022. This increase is quite significant compared to almost three decades earlier. In addition, data from satellite altimeters show that sea level rise along the eastern coast of the tropical Indian Ocean, including the coast of Java, is reaching a rate of 5.12 mm per year, which is higher than the global average of 3.1 mm per year. This indicates a significant increase in sea water temperature, an average of 0.4 degrees Celsius, based on analysis from 116 Meteorological, Climatological, and Geophysical Agency (BMKG) observation stations, as depicted in Figure 1.

Warmer ocean temperatures affect tuna distribution and migration patterns. Tuna species like bigeye and yellowfin tend to move to deeper and calmer waters, making them harder to catch. Shifts in water temperature and currents can disrupt tuna spawning grounds, affecting tuna reproduction rates and future stock levels. Yellowfin Tuna prefer sea temperatures between 20°C and 30°C, with 24°C to 28°C being ideal for breeding. Bluefin tuna thrive in calmer waters, but

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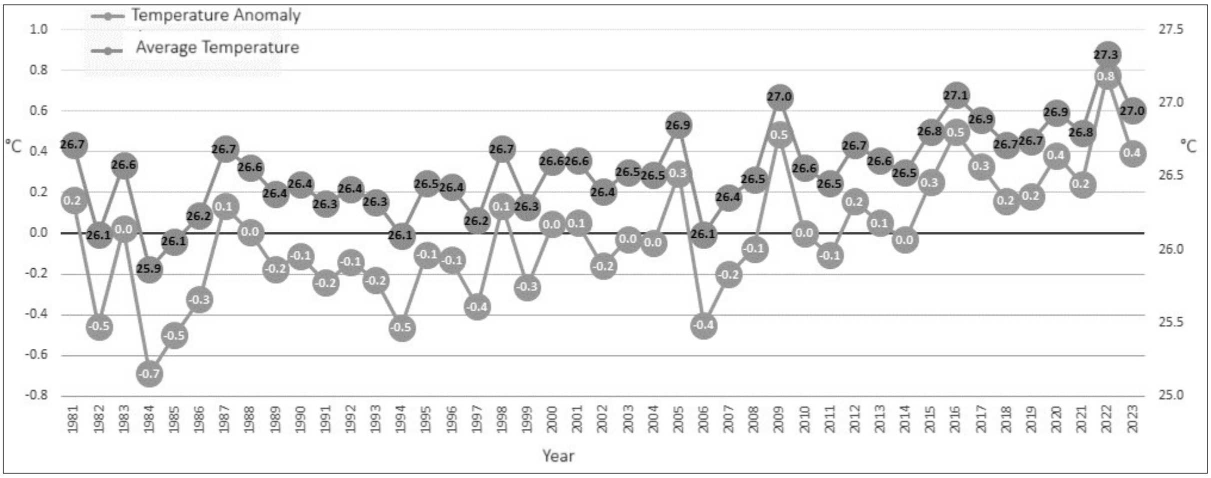

Figure 1. Indonesia's Average Air Temperature and Anomaly

spawning occurs in warmer waters, particularly 24°C to 28°C. Skipjack Tuna prefers warmer waters, with optimal conditions between 20°C and 30°C. Bigeye tuna are well-adapted to various temperatures but require slightly warmer conditions, around 24°C to 28°C for effective spawning. These tuna species are essential for egg development, larvae survival, and survival of larvae.

The FAO provides up-to-date information on climate change's impacts on marine fisheries. The report discusses the current anthropogenic stress and the projected effect of climate change on global marine fisheries. Research suggests that global fisheries productivity will decrease due to climate change(Erauskin-Extramiana et al., 2023). Previous studies discussing the problems related to financial risk in tuna fishing include the identification of suboptimal gear structures in the Bluefin tuna fishery, the need for draconian measures (Crutchfield, 1973) such as moratoria or gradual approaches to rebuilding the stock, and the challenges associated with arriving at a cooperative solution due to a large number of participating countries (Bjorndal & Brasão, 2011; Erauskin-Extramiana et al., 2023). Moreover, the tuna fishing industry is more profitable than fisheries even though other species have higher value, highlighting the significance of handling financial risk in tuna fishing (McKinney et al., 2020). Additionally, based on Dowling et al. (2015), the opportunity to enhance fishery revenue by adjusting fleet sizes and access fees emphasizes the consequences of cost management choices in tuna fishing.

As mentioned by Grafton & Kompas (2006), looking at the impact of fishing activities and assessing risks plays a crucial role in how fisheries managers evaluate and manage them efficiently. A practical risk analysis helps these managers grasp the uncertainties related to climate change and other factors influencing fish catches. For instance, findings from Wong et al. (2024) study indicate that shifts in fish migration patterns brought on by marine high temperatures could influence the accessibility of fish resources and consequently affect the economies relying on fishing. Climate change is now a player in shaping how fish move from place to place globally. Studies indicate that as water temperatures rise and salinity levels shift around in the seas and oceans, it can impact where different types of fish end up research by Hiddink & ter Hofstede (2008). For instance, fish usually found chilling out in waters are starting their way to warmer areas. This shift could change how marine ecosystems function and affect the fishing business that relies heavily on specific fish types, as highlighted by (Lavender et al., 2021). Recent data indicates that certain types of fish, like tuna and cod, are moving up to 200 miles north compared to years (Pinsky & Fogarty, 2012). This migration shift has implications for fish availability and the communities reliant on these species for their livelihoods; therefore, flexible and nimble fisheries management practices are necessary to address these shifts effectively. Furthermore, alterations in fish migration routes could impact the tuna supply chain. According to (Wong et al., 2024), tuna fish face pressure from both climate change and excessive fishing activities. Studies indicate that the decrease in tuna numbers could affect nations like Japan and Spain, which heavily depend on tuna trade exports for their economies to thrive.

Several research studies have dug down into the risk factors associated with tuna fishing across regions such as the Eastern Pacific Ocean (Vaca-Rodríguez & Enríquez-Andrade, 2006) and Sulawesi Island in Indonesia (Parenreng et al., 2016) and the Atlantic Ocean (Erauskin-Extramiana et al., 2023). These

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investigations have highlighted risk elements, including adherence to environmental management standards and practices related to quality control and maintenance (Paillin et al., 2022). The comparison between the profitability of tuna fishing and sea bream fishing has been made before. Tuna fishing is seen as lucrative but also riskier (Herrero, 2004). Studies on the Marshall Islands longline bigeye tuna fishery have highlighted a risk to species like sea turtles and sharks (Gilman et al., 2014). There have been suggestions for applying risk analysis methods developed for aquaculture to the tuna fishing industry (Arthur, 2008). The works of Duplisea et al. (2021) and Aaheim and Sygna (2000) have also contributed to this area of research. There is a focus on finding practical and efficient methods to integrate climate change considerations into fisheries recommendations in both cases mentioned above. In addition to this focus, The potential economic impacts of decreasing tuna populations and their movement westwards, highlighted by the latter study, emphasize the importance of developing policies and strategies to adapt to climate change.

Payne et al. (2021) study delves deeper into the European and worldwide tuna fishing industries, the former emphasizing the importance of custom climate adaptation measures and the latter predicting how climate shifts and economic changes will impact global skipjack tuna fisheries. Tidd et al. (2018) focus on the significance of using risk management tools and adaptable strategies when dealing with climate change impacts in the tuna fishing industry – pointing out how important it is to consider the vulnerability of tuna stocks and the effectiveness of management strategy evaluation, in achieving fishery goals as outlined in the sources cited discussing risk analysis and mitigation within this sector. Discussions often revolve around the impact of increasing tuna demand on the supply chain. Additionally, strategies for safeguarding and optimizing tuna stocks and the management implications for specific tuna fisheries are explored. Furthermore, risk analysis is discussed in guiding decisions related to fisheries management approaches (Dowling et al., 2015; Healey, 1984; Lane & Stephenson, 1998). These studies have some limitations, such as depending on simplified models and dealing with uncertainties in forcing scenarios. The importance of research in tackling particular risk factors and contributors in sustainable tuna supply chains is also emphasised in the papers. The significance of conducting risk analysis to examine the ecological aspects of ecosystems is highlighted, along with the need to evaluate strategy alternatives collectively in fisheries' decision-making processes.

However, specific implications for the global tuna fishing industry are rarely discussed. It involves understanding the economic value of the tuna fishing industry, assessing its risks, and considering the impacts of climate change on global fisheries, including tuna. So, from these findings, the formulation of the problem in this study is as follows: (i) How does climate change affect financial risks in the tuna fishing industry? (ii) How much does it increase or decrease? Moreover, (iii) how the share price of fishing companies is affected by climate change.

After examining and merging the past studies available in the field of research, this study stands out due to its innovative combination of financial risk evaluation alongside conventional risk assessment techniques developed by (Feng et al.(2024); and Lavender et al. (2021). Subsequently, in corroborating that, our research utilizes ALTMAN Z (Altman et al., 2017) to analyse how climate change significantly affects tuna industry profit and financial stability risk fishing activities and the performance of tuna companies' share fishing industry stocks. This methodology carries weight as it puts a numerical value on the financial risks linked to the influence of climate change on tuna harvesting operations, which is essential for making well-thought-out decisions regarding management strategies.

This study aims to investigate how climate change affects risks in the tuna fishing sector and examine if these risks influence the stock prices of tuna fishing companies significantly. Furthermore, the research will offer data-driven suggestions for policies that can help sustain the tuna industry amidst climate change challenges and provide policymakers with an insight into the economic impacts of various management approaches in dealing with climate variability. The study backs the advancement of fishing methods that can adjust to shifting environmental circumstances by assessing financial risks first and foremost. Furthermore, incorporating financial risk assessment helps strike a balance between the imperative for preservation and the economic aim of making a profit, thereby safeguarding the longevity of tuna fisheries. This study contributes to decision-making by offering a structure that considers biological and economic risks crucial for the sustainability of the fishing sector. Additionally, it highlights the importance of the fishing sector adjusting its methods in light of climate fluctuations, which are expected to change the locations and numbers of fish. The study adds to a strategy for managing fishing companies by taking into account the intricate relationship between climate change economic vulnerabilities and environmentally

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friendly fishing techniques.

Theoretical Background and Hypothesis Development

This study's theoretical foundations include climate change, financial risk, and fisheries management. Aaheim and Sygna (2000) state that climate change can affect fisheries' productivity through changes in habitat and fish migration patterns. Moreover, Campbell and Gallagher(2007) emphasize the importance of risk analysis in managing fishery resources to ensure sustainability. In this context, economic and ecological theories will be used to analyze the impact of climate change on the tuna industry. This method assesses risk using a mix of qualitative measures to emphasize the importance of enhancing data-gathering practices and cautiously addressing data gaps conservatively. However, the drawbacks of this method involve depending on a pool of data currently accessible, the consequences of illicit and unreported fishing activities on data deficiencies, and the incapacity to evaluate the effects on food chain dynamics because of uncertain probabilities.

When dealing with information on hand or when taking a cautious stance is considered while using risk analysis to evaluate the biological and ecological factors within fisheries ecosystems (Gilman et al., 2014), alternate management approaches are suggested to enhance both profitability and sustainability (Bjorndal & Brasão, 2011; Pfeiffer & Gratz, 2016). Adjusting the rates and format of access fees while reducing fleet sizes can significantly boost fishery revenue. Helped manage financial risks (Pfeiffer & Gratz, 2016). Nonetheless, it is essential to note that these approaches could lead to social, economic, and environmental consequences that require thorough evaluation (Tidd et al., 2018).

In the realm of evaluation and analysis, there are a variety of quantitative techniques, such as release evaluation and exposure assessment, as well as risk characterization and consequence assessment methods, that can be used to assess financial risk accurately (Ewald & Wang, 2010) (Ewald & Wangs, 2010). Additionally, a critical component of this process is using financial analysis tools, including capital budgeting instruments, enterprise budgets, cash flow assessments, and financial performance ratios, to evaluate the financial risks associated with any venture. Decision analysis principles, including decision trees, Bayesian decision networks, risk programming, stochastic efficiency, and multiple criteria/trade-off analysis, are well-established in financial risk analysis. These methods should be integrated in the early phases of hazard identification and risk assessment to effectively manage financial risk in aquaculture (Dowling et al., 2015; Healey, 1984; Lane & Stephenson, 1998).

H1: "Climate change increases high financial risks in the tuna fishing industry".
H2: "Climate change significantly impacts corporate profitability and results in financial risks in the tuna fishing industry".

Additionally to that observation, tuna fishing encounters financial jeopardy that greatly influences the profitability and endurance of the sector (Bjorndal & Brasão, 2011). Henceforth, comprehending and governing uncertainty is paramount in upholding the economic feasibility of tuna fishing undertakings impact on the volatility of a firm's share price in the tuna industry. Additionally, analyzing the risks plays a crucial role in guiding decisions related to where resources are allocated, how investments are made and overseeing day-to-day operations in order to ensure the durability of tuna fisheries profitability in the long run (Duplisea et al., 2021; Mullon et al., 2017). These disputes underscore the balance and difficulties involved in handling financial risks, within the tuna fishing sector (Crutchfield, 1973). Therefore, this study proposes the following hypotheses:

H3: "The financial risks of climate change significantly impact the stock prices of tuna fishing companies".

With this hypothesis, this study aims to test the relationship between climate change and financial risk. The following figure explains the framework of thinking (see Figure 2).

MATERIALS AND METHODS

Samples and Procedure

The data for this study were collected from seven Indonesian public companies engaged in the tuna fish trade, comprising the companies with the codes AA, AS, DI, CO, IN, EO and CB. Under research ethics and privacy, respondents ask to keep company names confidential and only provide initials for the company. Moreover, the secondary data collection period spanned from the first quarter of 2021 to the fourth quarter of 2023. These companies were selected based on their significant market presence and consistent reporting practices, ensuring the reliability and comprehensiveness of the data. The data were gathered through company reports from the Indonesia Stock Exchange (IDX) and capital market statistics from the Indonesia Financial Authority, or "Otoritas

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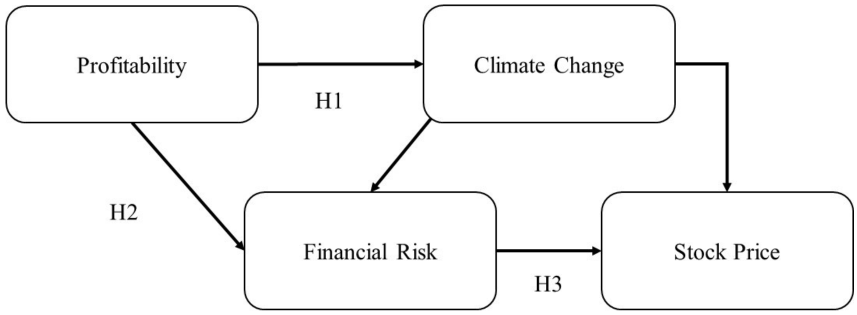

Figure 2. The Diagram of Research Framework

Jasa Keuangan" (OJK). In addition, sea temperature increase data is used as a dummy variable. The data on the increase in seawater temperature was obtained from the International Monetary Fund (retrieved from: https://climatedata.imf.org/pages/climatechange-data on 12 August 2024).

Measurements

This study incorporates data panels into The Altman Z-Score as they are widely used to assess the financial health of a company and its risk of bankruptcy (Altman et al., 2017). The Altman Z-Score is a financial metric to evaluate a company's bankruptcy likelihood. It is crucial to take into account that these benchmarks were first created for companies in the manufacturing sector and might differ depending on the industry dynamics and economic climate among variables. Modifications could be needed to analyze a sector or business model accurately. It merges five metrics that each reflect key elements of the company's activities into a single comprehensive score. Now, let us delve into these elements further. The Altman Z Score is a tool utilized to assess a company's status, particularly in terms of its risk of bankruptcy occurrence. It involves analyzing five ratios that offer insights into the company's financial well-being. Let us delve into each factor and uncover what it reveals about corporate operations.

The first thing to consider when calculating the Z Score is the ratio of working capital to total assets (WC/TA), which mainly looks at the liquidity aspects of a company's health. In essence, liquidity analysis revolves around juxtaposing a companys working capital (the difference between assets and current liabilities) against its assets. To simplify picture a company as a sailing ship where working capital serves as the fuel that keeps operations running when the ratio is high for that company. The presence of assets that can cover immediate obligations and sustain day-to-day operations is a good sign that the company is ready to handle unexpected expenses or economic challenges efficiently.

Now, lets take a look at the ratio of retained earnings to assets (RE / TA). This measure gives us insight into how much of the company's profits being reinvested in the business or distributed to shareholders, indicating a commitment to long-term growth and financial stability by putting accumulated profits back into operations or saving for future needs, like debt repayment. It shows a history of being successful and implementing management strategies to build a solid and long lasting business base.

Earnings Before Interest and Taxes to Assets (EBIT/TA) is the third factor we examine concerning operational efficiency. The income of the company prior to accounting for interest costs and taxes is denoted by Earnings Before Interest and Taxes (EBIT). By assessing EBIT in relation to assets we gain insight into how efficiently the company leverages its assets to create profits. This metric serves as a signal of the company's operational strength in terms of converting asset investments into tangible earnings. Having an EBIT to total assets ratio indicates that the company is earning good profits from its investments in a way that supports its long-term growth and ability to stay competitive in the market.

The MVE to TL ratio sheds light on how the market perceives the company's value by comparing its equity value. This reflects investors' estimation of the company's worth through its stock price. To its liabilities to gauge investor confidence in meeting financial obligations. When the MVE to TL ratio is high, it indicates that investors value the company more than its debts, showing trust in its health and performance, which is important for both internal evaluations and external investor support.

Sales to Assets (S/TA) is a metric that assesses how effectively a company can generate revenue from its assets and reflects the efficiency of asset utilization

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in generating sales revenue for the companys operations—a higher ratio signifies optimal asset utilization, for revenue generation and signifies efficient management of productive operations.

The combination of these five ratios results in a Z score number that reflects the financial stability of the company at a glance The higher the Z Score is rated, the lower the chances of bankruptcy are for a company If a company's Z Score is above 3 its financial security is generally assured but falls below 1.88, it signifies significant financial risk Ideally a Z Score, above 2.99 indicates solid financial standing and minimal risk of bankruptcy.

Data Analysis

In examining hypothesis 1 of this study, the research model regarding fishery enterprise proportions assessed by Altmans Z score to determine stability and bankruptcy risk among tuna fishing firms. The Altman Z Score is mainly employed to forecast the probability of a company facing bankruptcy within a set timeframe around one year in advance. The Altman Z-Score formula is a weighted sum of these ratios.

We add a term representing the dummy variable to incorporate a dummy variable into the Altman Z-Score model. Dummy variables are typically used to represent categorical data that represents whether there is an extreme climate change effect (1 if high-risk due to the climate change, 1 if not). The specific formula may vary slightly depending on the version used, but it generally looks like this:

$$Z=1.2X_{it1}+1.4X_{it2}+3.3X_{it3}+0.6X_{it4}+1.0X_{it5}+\beta D$$

Z= ALTMAN Z-Score (modified) ; X_1 =Working Capital / Total Assets; X_2 =Retained Earnings / Total Assets; X_3 =EBIT / Total Assets; X_4 =Market Value of Equity / Total Liabilities; X_5 =Sales / Total Assets
D =Dummy Variable; it =Pannel Data

The results of the Z Altman Score above will later be used to see how much financial risk increases when affected by climate change. Altman defined specific thresholds to classify companies into different risk categories. For example, a Z-score above 2.6 is considered safe, while a score below 1.1 indicates a high risk of bankruptcy. Furthermore, to test whether there is an effect of profitability on financial risk due to the increase in sea temperature, regression is used with an equation that uses sea temperature rise as an intervening variable:

$$\gamma=a\cdot X1+e1$$

$$Y1=b\cdot\gamma+c\cdot X1+e2$$

Furthermore, based on the existing data, panel data regression is continued to test the second hypothesis.

$$\gamma=a\cdot X2+e2$$

$$Y2=b\cdot\gamma+c\cdot X2+e3$$

Where, β=Coefficient; Y1= Altman Z Score; α=coefficient; Ln= Natural Logarithmic; X1=Sea temperature rise, β = constants; i=observation t = time period; ε = error term;

β=Coefficient; Y=Stock Price; α=coefficient; Ln= Natural Logarithmic; X2=Altman Z Score, D=dummy variable (1=climate change effect the financial risk/ 0=not)

Due to the nonlinear relationship between the dependent variables (stock price) and the independent variables (financial risk distress likelihood), these variables are transformed using a logarithmic scale across all seven companies; the results vary. Then, a Sobel analysis is conducted to evaluate whether the mediation effect is statistically significant. If the Sobel test is significant (p-value < 0.05), it suggests that the mediator carries a significant indirect effect from the independent variable to the dependent variable.

Since the data is panel data, we must decide whether it is under the fixed, common, or random effect. The selection of this model is very important because each model has different assumptions and implications for the analysis's results.

RESULTS AND DISCUSSION

Results

Sample Description

Table 1 is the result of descriptive statistics obtained from financial risk variables. After the normality test is carried out, use the Shapiro-Wilk test for each numerical variable in the data attached. The results show the W-statistic and P-value for each variable. Generally, if the p-value is less than 0.05, the data does not follow the normal distribution. The specific results for each variable are displayed in Table 2.

In addition, after a validity and reliability test was carried out, the reliability check was performed using Cronbach Alpha. We found the score of Cronbach

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Alpha is 0.88 (p-value > 0.05), and the Cronbach alpha item was deleted, showing all the items are above 0.05. meaning that the data is valid and reliable (see Table 3).

Let's proceed with the Chow test using the two halves of the dataset. As shown in Table 4, the p-value=0.0 of X^2 is significantly less than 0.05, indicating a statistically significant difference between the two groups (the first and second halves of the dataset). This suggests that there is no structural break or change in the relationship between the variables in the regression model across these two subsets of the data. This result implies that the regression model coefficients are stable across the two groups and could be pooled together under the

Table 1. Descriptive Statistics of Sample Analysis

	Current Assets	Current Liabilities	Working Capital	Total Assets	Ebit	Equity Market Value	Total Liabilities / Debts	Net Profit
Count	84	84	84	84	84	84	84	84
Mean	4.17E+11	4.33E+11	1.56E+11	1.15E+12	7.95E+10	6.92E+11	6.41E+11	8.13E+10
Std	6.77E+11	9.80E+11	5.03E+11	2.27E+12	1.89E+11	1.24E+12	1.38E+12	3.37E+11
Min	1.17E+10	2.30E+08	9.39E+08	6.87E+10	5.43E+07	4.17E+10	6.24E+09	1.40E+07
25%	9.31E+10	3.15E+10	4.21E+10	1.25E+11	4.05E+09	1.08E+11	4.13E+10	1.55E+09
50%	1.79E+11	1.11E+11	6.80E+10	2.91E+11	1.05E+10	1.49E+11	1.20E+11	4.95E+09
75%	2.46E+11	1.56E+11	1.17E+11	3.89E+11	2.18E+10	4.50E+11	1.77E+11	1.20E+10
Max	2.37E+12	5.22E+12	3.41E+12	7.04E+12	8.22E+11	5.66E+12	5.76E+12	2.21E+12

Table 2. Normality Test

Variable	W-Statistic	p-Value
Current Assets	0.54	9.95E-15
Current Liabilities	0.46	5.34E-16
Working Capital	0.21	4.15E-19
Total Aset	0.47	6.15E-16
EBIT	0.46	4.45E-16
Equity Market Value	0.55	1.05E-14
Total Liabilities / Debts	0.48	9.37E-16
Net Profit	0.24	8.62E-19

Table 3. Validity Test

Cronbach α=0.88	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
VAR00001	0.96	0.85
VAR00002	0.91	0.84
VAR00003	0.49	0.87
VAR00004	0.97	0.87
VAR00005	0.87	0.88
VAR00006	0.23	0.89
VAR00007	0.99	0.88
VAR00008	0.93	0.84
VAR00009	0.98	0.83
VAR00010	0.56	0.88
VAR00011	0.55	0.88

Table 4. Model Fit Test

Chow Test	Value
Cross-section X^2	20.85***
Probability	0.00

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fixed effect.

Hypothesis Testing

The dummy variable (1 indicating a high-risk industry and 0 indicating otherwise) reveals several key patterns and effects on the companies' Altman Z-Scores, measuring financial stability. For most companies, being classified as part of a high-risk industry due to climate change correlates with a notable decrease in their Altman Z-Scores. This decrease reflects the added financial vulnerabilities of operating in sectors heavily influenced by external environmental risks. The magnitude of the decrease in Z-Scores varies across companies and quarters, suggesting that the extent of vulnerability to climate-related risks is not uniform.

Significant reductions in financial stability scores are illustrated in Figure 3. Many companies, such as CB and DI, experience substantial reductions in their Z-Scores, often ranging from 25% to over 50%. These reductions highlight the severe impact of being in a high-risk industry on their perceived financial health. For example, DI's Z-Score drops by as much as 57% in Q2 of 2023, suggesting heightened financial instability. Similar trends are observed with companies like AS and IN, where the effects of being in a high-risk industry lead to consistent and considerable reductions in their scores across multiple quarters. In the meantime, the effects of the dummy variable are not uniform; they fluctuate across different companies and over time. Companies like AA and EO show varying degrees of Z-Score reduction, ranging from around 16% to over 50%.

Interestingly, some companies, such as CO, exhibit negative and positive changes in their Z-Scores when classified as high-risk. For example, CO shows a positive effect (+18%) in Q1 2022 and a smaller positive effect (+1%) in Q3 2022. In the meantime, specific companies, like DI, display a more consistent trend in the impact of the dummy variable, showing substantial reductions in Z-Scores across multiple quarters. In contrast, other companies like AA and EO show more fluctuations.

Based on the analysis presented in Table 5, we examined two different models to understand the relationships between key financial and environmental variables, specifically Profitability, Sea Temperature, Financial Risk, and Stock Price. Each model aimed

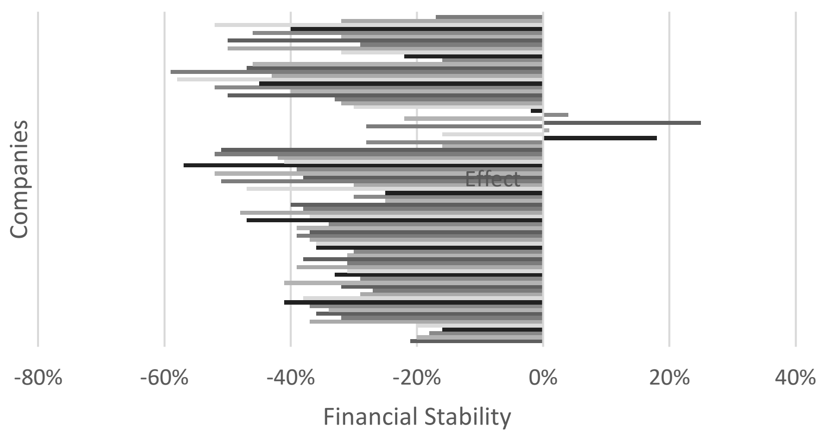

Figure 3. The Effect of Climate Change on Financial Stability Risk

Table 5.The Relationship Among Variables and Robustness Test

Relationship	R^2	α	β	M	F-stat	Sobel Test Result	Results
Profitability→ Sea Temperature → Financial Risk	0.64	0.16	-0.04	0.56	6.93** (0.040)	0.704** (0.035)	Supported
Financial Risk → Sea Temperature→ Stock Price	0.43	0.96	-0.57	0.43	6.27*** (0.002)	0.211* (0.833)	Not Supported

Note:*p-value Â 0.10. **p-value Â 0.05, *** p-value Â 0.01
Source: Authors' estimation.

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to test whether Sea Temperature acts as a mediating variable in these relationships.

First Model: Profitability → Sea Temperature → Financial Risk

The first model investigates whether Sea Temperature mediates the relationship between Profitability and Financial Risk. The analysis shows that the combined effects of Profitability and Sea Temperature can explain 64% of the variation in Financial Risk. The direct effect of Profitability on Sea Temperature is relatively modest, with a coefficient of 0.16, indicating a small positive association. Conversely, the indirect effect of Sea Temperature on Financial Risk is negative but minimal, with a coefficient of -0.04.

The mediation effect, represented by the value of 0.56, suggests that Sea Temperature partially mediates between Profitability and Financial Risk. The model is statistically significant, as indicated by an F-statistic of 6.93 and a p-value of 0.040. Moreover, the Sobel test, which assesses the significance of the mediation effect, yields a test statistic of 0.704 with a p-value of 0.035. This result confirms that the mediation effect is statistically significant at the 5% level. Therefore, we conclude that Sea Temperature significantly mediates the relationship between Profitability and Financial Risk, supporting the mediation hypothesis.

Second Model: Financial Risk → Sea Temperature → Stock Price

Discussion

Impact of Being in a High-Risk Industry

The data reveals that while companies in high-risk industries generally face lower financial stability scores due to their exposure to climate change, the extent of this impact is influenced by individual circumstances. Companies with less fluctuation or smaller reductions in their Z-Scores, such as EO and IN, may have more effective risk management strategies or business models that are less sensitive to climate risks. This underscores the significance of taking measures in risk management and employing adaptable strategies to minimize the negative consequences of operating in a high-risk sector like AA and EO exhibit varying responses to climate-related risks within high-risk industries, indicating that certain companies excel at handling them better than others during specific times. The improvements seen in company CO performance may be influenced by financial indicators or external factors that help lessen the dangers linked to operating in a high-risk sector, like strategic adjustments made by the company or better market conditions due to successful cost management strategies put in place. The consistent patterns observed in enterprise DI data suggest a continued susceptibility to risks associated with climate change impacts. On the other hand, a contrasting scenario can be noted in firms such as AA and EO, where there is fluctuation in how climate change affects their financial stability; this could imply varying levels of risk exposure or differences in how effectively they handle these risks over time.

Understanding the Mediation of Sea Temperature in Financial Risk Management

The significant correlation found between Sea Temperature and the relationship between Profitability and Financial Risk indicates that environmental elements such as sea temperature can have an impact on financial results. One potential reason for this is that industries affected by changes in the environment – like fishing sectors and tourism – may see changes in profitability that are strongly tied to conditions. For instance, warmer sea temperatures could result in decreased fish populations or coral damage and heightened hurricane activity, which could adversely affect profitability.

In response to shifting conditions impacting profitability levels, firms may alter their financial approaches to minimize risks by boosting their capital reserves or modifying investment and supply chain management tactics. In these industries, companies must incorporate environmental factors into their financial risk management strategies proactively.

Why the Mediation Effect Does Not Extend to Stock Prices

The lack of a clear connection between Sea Temperature and Stock Price as a mediator for Financial Risk implies that the influence of environmental aspects on stock values is not straightforward but rather intricate. This discovery could indicate the elements involved in determining stock prices; they are shaped by various factors extending beyond just financial risk or environmental circumstances.

Stock prices are typically influenced by market predictions and sentiment from investors, as well as broader economic indicators and financial market trends. Changes in conditions that raise financial risk may not prompt immediate reactions from investors

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unless there is a noticeable impact on future earnings or dividends. For instance, A company's stock price may not adjust to the risks linked to rising sea temperatures until these risks result in actual financial losses or expenses for the company's operations. Henceforth, businesses could employ techniques to hedge risks or clearly convey their risk reduction strategies to investors to lessen the perceived effect on their stock values.

CONCLUSION

The findings suggest that changes in Sea Temperature play a role in connecting Profitability and Financial Risk but do not connect Financial Risk and Stock Price directly. These results emphasize the connections between financial and environmental elements and imply that mediation effects can vary across different scenarios. In summary, the study results indicate that while environmental factors such as sea temperature can influence financial relationships significantly, not all financial outcomes are equally impacted by them. This underscores the importance of grasping the ways in which changes in the environment impact financial results and recognizing the significance of incorporating environmental factors into business strategy and financial risk management models effectively implemented by companies and policymakers to adeptly navigate the complexities and possibilities presented by a progressively evolving and interlinked global context.

The discoveries hold meaning for both business tactics and environmental regulations. For corporations operating in environmentally delicate industries, it is essential to grasp the effects of environmental variables like ocean temperature on financial performance and to integrate these factors into their financial planning and risk assessment frameworks. This might include enhancing infrastructure resilience, broadening revenue sources, or adopting eco practices that lower vulnerability to environmental risks. For policymakers, the findings emphasize the necessity of crafting measures that assist companies in managing risks. Businesses could be encouraged to embrace practices by offering incentives and investing in eco-friendly technologies to address climate change impacts effectively and enhance their resilience against environmental challenges. This data may also assist agencies in comprehending the indirect impact of environmental shifts on economic stability through effects on profitability and financial risk.

Although the research offers perspectives to consider, some drawbacks need to be kept in mind as well. The models fail to consider every factor that could impact the analyzed relationships, like broader economic trends and changes in policies and technology. Furthermore, the data employed may not completely reflect the changing and dynamic nature of these relationships over time.

The studies should focus more broadly to grasp the direct and indirect impacts at hand in a better way. Long-term research could offer a profound understanding of how these connections develop over time, especially within the changing climate scenario. Moreover, delving into industry examinations may shed light on how various sectors respond to environmental shifts and bolster the overall relevance and usefulness of the results.

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