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Model Sensitivity in Early Warning Systems: Evidence from Conventional and Islamic Insurance in Indonesia

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Abstract

This study examines how Early Warning System (EWS) model design influences financial risk detection and decision-making relevance in conventional and Islamic insurance. It addresses whether a single EWS model can be applied reliably across structurally different insurance systems. A quantitative comparative-longitudinal design was applied over 2019–2024 using data from two Indonesia Stock Exchange-listed insurance companies. Seven NAIC-based financial ratios were normalized using z-scores and constructed into three model variants: simple averaging, NAIC threshold, and an Enhanced model incorporating liquidity and operational indicators. Hypotheses were tested using Shapiro–Wilk, independent t-tests, and Mann–Whitney U tests. The results show that simple averaging fails to differentiate financial fragility ($p = 0.607$), while the NAIC Threshold model produces a highly significant distinction ($p < 0.001$), strengthened by the Enhanced model ($p = 0.0099$; $R^2 = 0.50$). The Islamic insurer exhibits higher fragility during 2022–2024, driven by liquidity pressure and operational inefficiency. These findings challenge the assumption that generic EWS models perform equivalently across systems. Applying conventional EWS models without structural adaptation leads to biased risk interpretation in Islamic insurance and may delay early risk detection. The study provides implications for risk management, regulatory supervision, and investor-oriented early warning analysis.

Keywords: Early Warning System; financial fragility; Islamic insurance; risk management; model sensitivity.

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INTRODUCTION

The financial failure of insurance companies carries consequences beyond the balance sheet: it erodes policyholder confidence, disrupts claims settlement, and may trigger systemic instability (Minsky, 1987; IAIS, 2024). Therefore, the ability to detect emerging financial stress is a critical component of effective risk management. Early Warning System (EWS) models are widely used to identify financial fragility before it escalates into crisis. yet it remains unclear whether a single EWS model can be applied reliably across structurally different insurance systems.

The global economic environment has uncertainty, which may affect the insurance industry. In Indonesia, the life insurance sector reported total revenues of Rp174.21 trillion as of September 2025, reflecting a growth of 3.2% (AAJI, 2025). However, beneath this aggregate growth, a divergence between participation and financial performance, where the number of insured individuals increased by 12.8% while premium income declined by 1.1% during the same period. This contrast suggests that aggregate indicators may obscure underlying financial pressures at the firm level. Growth in participation does not necessarily translate into stronger financial performance, as pressures may emerge across underwriting results, claims, and operational efficiency. This divergence highlights the need for early detection tools capable of identifying latent financial risks before they become visible in formal solvency measures.

Financial fragility develops through the gradual accumulation of pressures across liquidity, capital structure, and operational efficiency (Minsky, 1987; Brunnermeier, 2024). In the insurance context, these pressures rarely occur in isolation; underwriting deterioration, rising claims, and operational inefficiencies tend to emerge simultaneously before conventional indicators signal distress. Detecting such multi-dimensional risk requires an EWS framework capable of capturing multiple sources of financial stress. The design of the EWS model determines which risks are captured and which remain systematically undetected.

Previous studies on EWS in insurance primarily focus on statistical accuracy and predictive performance, often using single-model approaches or period-based analysis (Dwianika et al., 2024; Raissa et al., 2025; Setianingsih et al., 2024; Susanti & Muntiah, 2024). These studies tend to treat EWS as a neutral measurement tool, overlooking that model construction may influence detection outcomes. Moreover, most models are developed within conventional financial systems and applied generically across contexts. As a result, limited attention has been given to how model performance varies across structurally different insurance systems. This limitation is not merely methodological but

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also managerial, as inappropriate model selection may lead to delayed or misaligned risk responses.

This gap is critical because conventional and Islamic insurance operate under fundamentally different risk structures. Conventional insurance relies on risk transfer, whereas Islamic insurance (takaful) is based on risk-sharing with mandatory separation between participant and operator funds. These differences create distinct liquidity dynamics and risk patterns, particularly in how financial stress emerges and is transmitted across operational and funding structures. Applying conventional EWS models without structural adaptation may therefore lead to biased risk interpretation in Islamic insurance.

Based on this gap, this study aims to evaluate how EWS model construction influences financial fragility detection and its relevance for decision-making across conventional and Islamic insurance. Two hypotheses are tested: (H1) there is a significant difference in financial fragility between conventional and Islamic insurance using NAIC-based EWS ratios; and (H2) an extended model incorporating liquidity and operational indicators provides higher sensitivity than the classical model.

This study contributes in three ways. First, it shifts EWS analysis from statistical accuracy toward decision-making relevance, emphasizing its role as a managerial tool rather than a purely analytical instrument. Second, it demonstrates that conventional EWS models are not fully adaptive to Islamic insurance risk characteristics, highlighting the potential for systematic bias. Third, it proposes a contextual framework for selecting EWS models based on analytical objectives, offering practical guidance for risk management and supervisory evaluation.

LITERATURE REVIEW

Financial fragility in the insurance context refers to a condition in which accumulated structural pressures across multiple financial dimensions reduce a firm's capacity to absorb adverse shocks (Brunnermeier, 2024; Minsky, 1987). Unlike banking crises, which often manifest abruptly, insurance fragility typically develops gradually, first appearing in underwriting deterioration and operational inefficiency before becoming visible in capital adequacy indicators (Cummins et al., 2013; IAIS, 2022). This gradual evolution creates a critical managerial challenge: when detection relies solely on formal solvency metrics, intervention is systematically delayed.

Financial fragility in insurance is also influenced by structural characteristics such as diversification and interconnected risk exposure, which may amplify systemic vulnerability, thereby reinforcing the multidimensional nature of insurance fragility

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(Regele, 2022). This highlights that risk does not emerge solely from solvency deterioration, but from a broader set of interacting financial and structural factors.

Empirical studies highlight the importance of liquidity and operational indicators in assessing insurance financial conditions. Liquidity and other EWS-based financial ratios have been shown to significantly influence solvency levels, indicating their relevance as key components in financial monitoring (Prayogi et al., 2023). In addition, liquidity plays a critical role in shaping firm performance, although its relationship with financial outcomes may vary across conditions (Ratajczak et al., 2024). Operational efficiency and cost structures are also central to firm performance in the insurance industry (Cummins et al., 2013). Taken together, these findings suggest that financial fragility is inherently multi-dimensional and support the need for EWS frameworks capable of capturing early-stage signals across liquidity, operational, and structural dimensions.

The most widely applied Early Warning System in insurance is the Insurance Regulatory Information System (IRIS) developed by the National Association of Insurance Commissioners (NAIC, 2025), which consists of a set of analytical solvency tools and financial ratios designed to screen and evaluate the financial condition of insurers. The system supports regulators in identifying companies that require closer supervisory attention and in allocating regulatory resources more efficiently.

In Indonesia, financial monitoring of insurance companies is conducted through a regulatory framework established under POJK No. 71/POJK.05/2016, which evaluates financial soundness based on solvency, technical reserves, investment adequacy, and equity (POJK, 2016).

Empirical evidence further confirms that early warning approaches in insurance benefit from multi-indicator frameworks that integrate firm-level characteristics, macroeconomic conditions, and financial market variables. Recent research demonstrates that incorporating these dimensions significantly improves the ability to predict insurer insolvency and detect early-stage financial distress (He et al., 2023). These findings reinforce the role of EWS as a forward-looking analytical tool that extends beyond static solvency assessment toward a more comprehensive detection of financial fragility.

However, existing EWS research—particularly in Indonesia—remains predominantly descriptive and model-static. Studies by Astuti (2024), Setianingsih et al. (2024), and Raissa et al. (2022) apply EWS ratios to assess financial conditions at specific points in time without evaluating how model construction influences detection outcomes. Dwianika et al. (2024) compare firms but do not examine sensitivity across alternative

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model designs. As a result, EWS is commonly treated as a neutral measurement tool rather than as a design-dependent analytical framework.

This limitation is not only methodological but also managerial. When model construction is assumed to be neutral, differences in detection outcomes may be misinterpreted as actual financial conditions, rather than consequences of model structure. As a result, decision-making based on such models risks being biased or delayed, particularly when early-stage stress signals are not adequately captured.

International evidence reinforces this concern. Altman, et. al. (2017) show that equal-weight composite models consistently underperform threshold-based approaches in distinguishing financially distressed firms. While widely acknowledged in corporate and banking contexts, this insight remains underexplored in insurance EWS design, particularly in emerging markets.

Islamic insurance (takaful) operates under a fundamentally different risk architecture compared to conventional insurance. Instead of transferring risk to the insurer, takaful employs a risk-sharing mechanism based on tabarru', where participants contribute to a collective fund used to cover mutual losses. In this system, tabarru' funds are managed as pooled participant contributions that are specifically allocated for claim payments and risk-sharing purposes, rather than as proprietary funds of the insurer (Poetra & Hendranastiti, 2024; Rahmadhani et al., 2024).

A defining structural feature of takaful is the separation between participant funds and operator funds, which reflects the distinction between risk ownership and fund management. This separation constrains the insurer's direct access to liquidity and fundamentally alters the dynamics of financial management compared to conventional insurance systems. As a result, financial performance and risk exposure in takaful are not determined solely by solvency conditions, but are closely linked to the management of tabarru' funds, including contributions, claims, and investment returns. The dependence on tabarru' funds as the primary source of claim financing further implies that financial outcomes are shaped by the balance among these components, rather than by capital adequacy alone, leading to distinct financial dynamics in liquidity management and operational cost structures within takaful institutions (Ramadhani et al., 2023).

In addition, the allocation and management of tabarru' funds are influenced by internal factors such as claim expenses, operational costs, and asset structure, which directly affect financial outcomes and risk exposure (Poetra & Hendranastiti, 2024). These characteristics indicate that liquidity and operational dimensions play a critical role in shaping the financial condition of Islamic insurance institutions.

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Empirical applications further show that financial evaluation in takaful relies not only on solvency measures but also on liquidity, profitability, and operational indicators within frameworks such as the Early Warning System (EWS) (Aurelia & Mubarrok, 2025). This suggests that risk signals in Islamic insurance emerge through multiple financial channels, rather than being captured solely by traditional solvency-based metrics.

These findings imply that applying conventional EWS frameworks—particularly those centered on solvency indicators—without structural adaptation may fail to capture the most relevant sources of risk in Islamic insurance. Consequently, models that appear statistically valid in conventional contexts may produce systematically biased interpretations when applied to takaful institutions.

Despite extensive application of EWS models in insurance research, a critical gap remains. Existing studies largely focus on single-model applications, cross-sectional comparisons, or static assessments of financial health. Very limited attention has been given to evaluating how different EWS model constructions influence detection sensitivity, particularly in a longitudinal setting and across structurally different insurance systems.

More importantly, prior research rarely integrates methodological evaluation with managerial relevance. EWS outputs are typically treated as final indicators rather than as inputs for decision-making, thereby overlooking the practical consequences of model selection. This limitation becomes more pronounced in the context of Islamic insurance, where structural differences in risk dynamics challenge the validity of conventional model assumptions.

Most studies are limited to single-model applications, lack longitudinal validation, or do not incorporate institutional differences in risk structure. This positioning highlights a clear gap not only in methodological design but also in the practical relevance of EWS models for decision-making.

This study contributes to the literature in three key ways. First, it reconceptualizes EWS as a decision-support tool rather than a purely statistical measurement instrument, emphasizing that model construction shapes risk detection outcomes. Second, it demonstrates that EWS models developed in conventional financial contexts are not fully adaptive to the structural characteristics of Islamic insurance, highlighting the risk of systematic bias when generic models are applied. Third, it proposes a contextual framework for selecting EWS models based on analytical objectives, distinguishing between models suitable for early detection and those more appropriate for confirmatory decision-making.

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By integrating methodological evaluation, institutional context, and managerial relevance, this study advances both the EWS literature and the practice of financial risk management in insurance.

RESEARCH METHOD

This study employed a quantitative comparative-longitudinal case-based design to evaluate the sensitivity of Early Warning System (EWS) model construction in detecting financial fragility across two structurally different insurance companies over the period 2019–2024. The case-based approach was selected to enable analytical comparison between contrasting risk architectures rather than broad statistical generalization. The focus of the study was to examine whether differences in EWS model construction systematically influence detection outcomes when applied to fundamentally different insurance systems. This approach follows the logic of analytic generalization, where findings are interpreted in relation to theoretical mechanisms rather than population-level inference (Yin, 2018). The longitudinal structure further allowed the analysis to capture changes in financial fragility over time, ensuring that model sensitivity was assessed across both entities and temporal dynamics.

The data consisted of audited annual financial statements obtained from the Indonesia Stock Exchange and official company disclosures for the period 2019–2024. The sampling process followed a purposive approach to ensure comparability and data consistency. The selection criteria emphasized similarity in asset scale to reduce distortion in financial ratio interpretation, as well as completeness and consistency of financial reporting throughout the observation period to maintain balanced panel data.

Based on these criteria, PT Asuransi Ramayana Tbk (ASRM) was selected to represent conventional insurance, while PT Asuransi Maximus Graha Persada Tbk (ASMI) represented Islamic insurance operating under a tabarru'-based risk-sharing structure with mandatory separation between participant funds and operator funds. Both companies operate in the general (non-life) insurance segment, ensuring comparability in risk exposure and product characteristics.

The final dataset consisted of 12 firm-year observations. This sample size was appropriate for the comparative statistical procedures applied in this study, particularly for non-parametric testing, and is consistent with prior research employing focused case-based designs in the insurance sector.

Financial fragility was measured using seven financial ratios representing key dimensions of insurance performance. Five ratios were derived from the NAIC IRIS

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framework, covering capital adequacy, underwriting performance, claims burden, leverage, and risk retention (NAIC, 2025). To enhance the sensitivity of the model, two additional indicators were incorporated, namely the cash-to-liabilities ratio as a proxy for real liquidity capacity and the operating expense-to-net premium ratio as an indicator of operational stress (Cummins et al., 2013; Altman, et. al., 2017)

All ratios were calculated using standard industry formulas without modification to ensure comparability with regulatory benchmarks and prior empirical studies. To maintain consistency in interpretation, all variables were transformed into a uniform directional scale in which higher values indicate higher levels of financial fragility. The detailed formulation of variables and their operational definitions follows the structure presented in the original measurement table. The operational definitions of all variables are presented in Table 2.

Table 2. Operational Definition of Variables

Code	Ratio Name	Operational Definition	Risk Dimension	Source
R1	Capital Ratio	Capital / Total Assets	Solvency	NAIC (2020)
R2	Underwriting Ratio	Underwriting Result / Net Premium	Technical Performance	NAIC (2020)
R3	Claims Ratio	Net Claims Expense / Net Premium	Claims Risk	NAIC (2020)
R4	Liabilities Ratio	Total Liabilities / Total Assets	Leverage	NAIC (2020)
R5	Retention Ratio	Net Retention Premium / Gross Premium	Risk Structure	NAIC (2020)
R6	Cash Ratio	Cash & Cash Equivalents / Total Liabilities	Real Liquidity	Altman et al. (2017)
R7	Operating Expense Ratio	Operating Expenses / Net Premium	Operational Stress	Cummins et al., 2013

Source: Compiled from regulatory standards and industry literature, 2025

The variables defined above were not only used as continuous financial indicators but also evaluated against established regulatory and industry benchmarks to determine their risk signaling function. In this study, threshold criteria play a critical role in distinguishing between normal financial conditions and potential early-stage fragility. These thresholds reflect normative standards commonly applied in supervisory and

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industry practices, allowing the EWS models to capture deviations that may not be apparent through aggregate scoring approaches. Accordingly, the threshold standards used for model construction are presented in Table 3.

Table 3. Assessment Threshold Standards

Ratio	Standard	Source
Solvency (Capital Adequacy Ratio)	> 120%	OJK (POJK No. 71/2016)
Liquidity Ratio	> 100%	NAIC (IRIS Ratio Manual)
Claims Expense Ratio	< 70%	A.M. Best Industry Standard
Underwriting Ratio	> 0	NAIC IRIS Performance Criteria
Net Retention Ratio	> 50%	Vaughan & Vaughan / Industry Benchmark
Operating Expense Ratio	< 30%	A.M. Best Efficiency Standards

Source: Compiled from regulatory standards and industry literature, 2025

Based on these variable constructions and threshold criteria, the analytical procedure was conducted in two stages. The analysis was conducted through a structured two-stage procedure. In the first stage, all financial ratios were standardized using z-score normalization to ensure comparability across variables with different measurement scales. Ratios that were conceptually associated with financial strength were transformed by reversing their sign so that all indicators consistently reflected financial fragility.

Following normalization, three EWS model variants were constructed based on different aggregation logics. The first model applied a simple composite index using equal-weight averaging of all ratios. The second model adopted the classical NAIC threshold-based approach by identifying deviations from regulatory benchmarks. The third model extended the NAIC framework by incorporating liquidity and operational indicators to capture additional dimensions of risk. This multi-model construction enabled a direct comparison of how different model designs influence detection sensitivity while holding the underlying data constant.

In the second stage, hypothesis testing was conducted to compare financial fragility levels between the conventional and Islamic insurance companies across all model variants. The normality of the data was assessed using the Shapiro–Wilk test. When the

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normality assumption was satisfied, independent sample t-tests were applied. In cases where the assumption was violated, the Mann–Whitney U test was used as a non-parametric alternative. All statistical analyses were performed at a significance level of α = 0.05 using Gretl statistical software.

The analytical focus of this study was directed at evaluating the sensitivity of different EWS model constructions in distinguishing financial fragility between structurally different insurance systems, thereby linking methodological design to its implications for financial risk decision-making.

DISCUSSION

Financial fragility was tested across three model variants arranged in ascending order of indicator complexity. The staged approach was intentional because it allows direct attribution of sensitivity gains to specific design choices rather than conflating them with overall model effects.

Simple Composite Approach (Z-Score Aggregation)

Table 4. Descriptive Statistics — Simple Z-Score Aggregation

Company	n	Mean	Std. Dev.	Min	Max
ASRM (Conventional)	6	0.025	0.095	−0.062	0.176
ASMI (Islamic)	6	−0.025	0.212	−0.305	0.225

Source: Processed data, 2025

The results of the simple composite approach are presented in two parts. Table 4 summarizes the descriptive statistics of the aggregated z-score, while Table 5 reports the results of the independent t-test used to assess differences between the two companies.

Table 5. Independent t-Test Results — Z-Score Aggregation

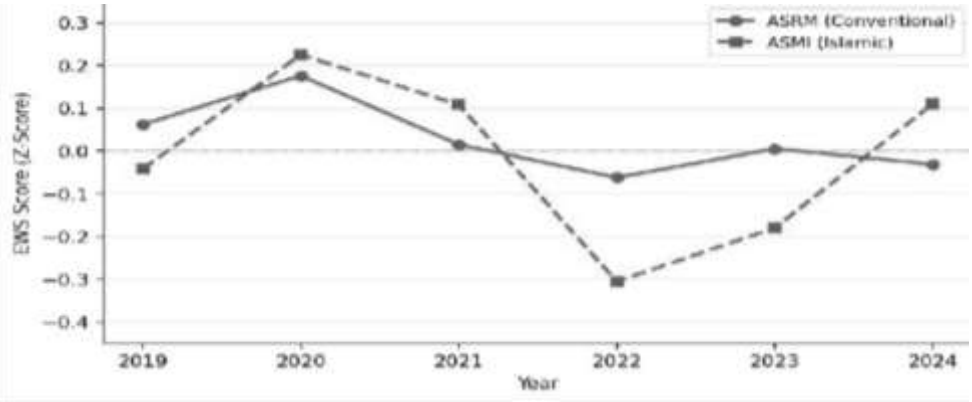
Variable	Coefficient	t-statistic	Df	p-value
ASRM vs ASMI	0.050	0.531	10	0.607 (ns)

Source: Processed data, 2025

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The simple composite approach returned no statistically significant difference between the two companies (p = 0.607). Mean scores were nearly identical in magnitude but opposite in direction (0.025 vs −0.025), though ASMI showed substantially higher score volatility (SD = 0.212 vs 0.095), and a wider score range (−0.305 to 0.225 vs −0.062 to 0.176). The non-significant result is consistent with Altman et al. (2017), who demonstrate that equal-weight linear aggregation systematically suppresses cross-dimensional variance—stability in one ratio cancelling pressure in another. The non-result here therefore reflects a methodological artifact rather than an absence of real fragility differences, as the subsequent models confirm.



Source: Processed data, 2025

Figure 1. EWS Score Trends — Simple Z-Score Aggregation (2019–2024)

Figure 1 shows that ASRM and ASMI scores fluctuate around zero with considerable overlap, yielding no consistent visual separation. This confirms that the simple aggregation model lacks the discriminatory power needed to distinguish structurally different fragility profiles.

NAIC Threshold-Based Early Warning System

Table 6. Mann–Whitney U Test Results — NAIC Threshold Model

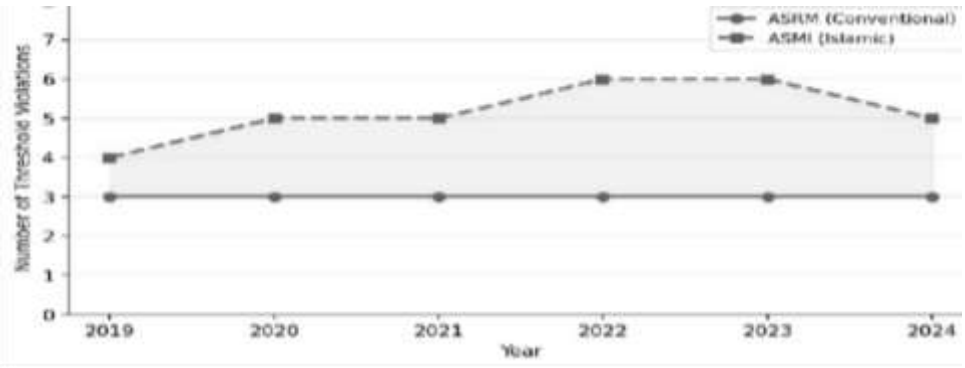
Comparison	Mean ASRM	Mean ASMI	U	p-value
ASRM vs ASMI	3.00	5.17	36.00	< 0.001 ***

*Source: Processed data, 2025 *** p < 0.001*

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Shifting from value aggregation to threshold-based counting produced a dramatic change in discriminatory power: $p < 0.001$, with ASMI averaging 5.17 threshold violations per period versus 3.00 for ASRM. This 72% higher violation rate was consistent across all six observation years. ASRM's stable score indicates that its ratio variations—while present—did not exceed regulatory safety boundaries. ASMI's persistent violations indicate systematic risk exposure that was invisible in the z-score model. This contrast directly supports the argument of Dwianika et al. (2024) that threshold-based evaluation is more effective than aggregate ratios in identifying financial health differences in Indonesian insurance. Critically, this jump in sensitivity was achieved purely by changing the aggregation rule—the underlying ratio data were identical.



Source: Processed data, 2025

Figure 2. NAIC Threshold Violation Scores (2019–2024)

Figure 2 illustrates the persistent and consistent separation between ASRM and ASMI throughout the full observation period, with ASMI maintaining higher violation counts in every year. The shaded area between the two series visually confirms the structural gap that the simple model failed to capture.

NAIC Enhanced Early Warning System

Table 7. Independent t-Test Results — NAIC Enhanced Model

Comparison	Mean Difference	T	Df	p-value
ASRM vs ASMI (R^2 = 0.50)	−0.367	−3.177	10	0.0099 **

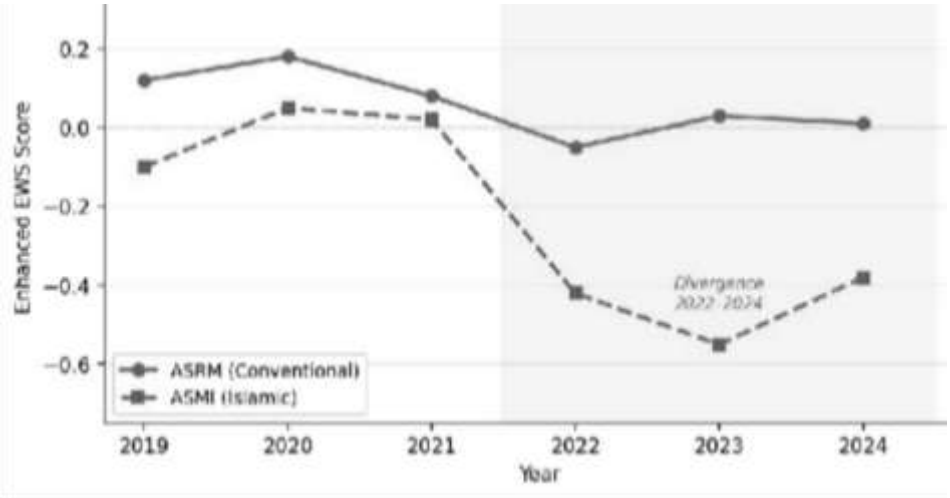
*Source: Processed data, 2025 ** p < 0.01*

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The NAIC Enhanced model yielded a mean score difference of −0.367 (p = 0.0099), with R^2 = 0.50 indicating that insurance system type accounts for half of the variance in fragility scores. The inclusion of R6 (cash-to-liabilities) and R7 (operating expense ratio) enhances the model's discriminatory capacity relative to prior specifications, suggesting that liquidity and operational efficiency dimensions play a critical role in differentiating financial conditions across insurance systems.

This result is consistent with prior evidence showing that operational efficiency indicators provide independent predictive power for insurance distress beyond solvency-based measures (Cummins et al., 2013). It also aligns with more recent findings that multi-indicator approaches—integrating liquidity, operational, and firm-specific variables—significantly improve the detection of early-stage financial distress in insurance institutions (He et al., 2023).



Source: Processed data, 2025

Figure 3. NAIC Enhanced Score Trends (2019–2024)

Figure 3 reveals a qualitatively different pattern from Figure 1. ASMI scores diverge sharply downward from 2022, reaching a trough in 2023–2024, while ASRM remains relatively stable throughout. The shaded divergence zone highlights the 2022–2024 period of elevated separation, which corresponds to post-pandemic economic normalization pressures that affected Islamic insurance liquidity dynamics more severely than conventional operations, consistent with the structural argument developed in Section 2.

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The three-model comparison reveals a clear and theoretically coherent progression across model specifications. The simple aggregation model shows no detection capability, the threshold-based model demonstrates strong discriminatory power ($p < 0.001$), and the enhanced model provides the sharpest detection performance ($p = 0.0099$, $R^2 = 0.50$). This progression is not a statistical artifact, but rather reflects three distinct mechanisms through which model design shapes detection sensitivity and analytical interpretation.

First, equal-weight linear aggregation suppresses cross-dimensional variance. When a stable capital ratio offsets a deteriorating cash ratio in a simple average, the composite score appears neutral even as underlying liquidity pressure increases. This mechanism explains the non-significant result observed in Model 1 and highlights a key limitation of composite averaging approaches. It also helps explain why prior EWS studies that rely on aggregate indices may fail to fully capture differences in financial fragility across institutions (Dwianika et al., 2024).

Second, threshold-based evaluation restores sensitivity by converting continuous ratio values into categorical risk signals. In this approach, each ratio is assessed according to whether it exceeds predefined regulatory safety thresholds, thereby directly operationalizing its normative interpretation. This method is more diagnostically informative than relying on average deviations because it captures boundary-based risk conditions more explicitly. This explains why the NAIC Threshold model, despite using the same underlying data as Model 1, produces results that are substantially more statistically significant.

Third, indicator scope determines which risk dimensions become visible. The superiority of the Enhanced model over the classical NAIC model is attributable to R6 and R7, which capture two dimensions that are particularly salient for Islamic insurance, namely real liquidity capacity and operational efficiency under fund-separation constraints. In tabarru'-based insurance, the structural separation between participant funds and operational funds allows the operator's cash position to deteriorate independently of formal solvency metrics. R6 directly measures this dimension, whereas the classical NAIC framework does not.

This third mechanism has a critical implication extending beyond this study. Applying solvency-centric EWS frameworks to Islamic insurance companies, as commonly found in prior Indonesian research, indicates that conventional EWS frameworks may be structururally less sensitive to the most relevant risk channels within that business model. The finding is therefore not merely that Islamic insurance is more

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fragile, which represents the factual result, but rather that conventional EWS frameworks are not adequately adapted to detect fragility in Islamic insurance, which constitutes the methodological contribution. This distinction is important for both research design and regulatory practice.

For insurance company management, particularly within Islamic insurers, the NAIC Enhanced model provides an actionable early-warning dashboard capable of detecting stress before formal solvency thresholds are breached. Management may consider monitoring R6 and R7 on a quarterly basis alongside RBC indicators. A declining cash ratio combined with a rising operating expense ratio should trigger board-level review of liquidity reserves and cost structure, regardless of whether the RBC ratio remains within OJK regulatory bounds. The 2022–2024 pattern in ASMI demonstrates that this combination of signals preceded the period of highest measured fragility, which reflects precisely the early-warning function the model is intended to serve.

For Otoritas Jasa Keuangan as the supervisory authority, these findings provide empirical grounds for considering an expansion of the insurance monitoring framework. Integrating cash-based liquidity ratios and operating expense ratios into SEOJK supervisory guidelines, particularly for Islamic insurance entities, would improve the ability to detect emerging fragility before it reaches insolvency thresholds. This recommendation is consistent with International Association of Insurance Supervisors Insurance Core Principles, which emphasize supervisory frameworks capable of capturing multidimensional risk rather than relying solely on capital adequacy metrics.For investors and financial analysts, divergence between a company's classical NAIC score and its Enhanced score functions as a material early-warning signal. When a company's classical EWS score appears stable while its Enhanced score trends adversely, this gap indicates latent financial stress not yet reflected in publicly reported solvency figures. In equity and fixed income analysis of insurance-sector securities, this divergence indicator could be incorporated as a screening variable alongside traditional financial ratio analysis.

CONCLUSION

This study evaluates the sensitivity of three Early Warning System (EWS) model constructions in detecting financial fragility differences between conventional and Islamic insurance companies over the period 2019–2024. The findings demonstrate that EWS model construction is not a neutral methodological choice, but a determining factor in what risks are detected, when they are detected, and how accurately they are interpreted.

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The results show that simple composite aggregation fails to differentiate fragility ($p = 0.607$), confirming that equal-weight averaging suppresses cross-dimensional risk signals. In contrast, the NAIC Threshold model produces a highly significant distinction ($p < 0.001$), while the NAIC Enhanced model delivers the strongest discriminatory power ($p = 0.0099$; $R^2 = 0.50$) by incorporating liquidity and operational indicators. These findings highlight that expanding indicator scope is essential for capturing risk dimensions that remain structurally invisible in solvency-based frameworks, particularly in Islamic insurance systems characterized by fund separation.

This study contributes to the literature by demonstrating that EWS models developed within conventional insurance frameworks may be structurally misaligned when applied to Islamic insurance contexts. The implication is not that Islamic insurance is inherently more fragile, but that measurement frameworks must be aligned with the structural characteristics of the system being evaluated.

From a practical perspective, the findings underscore the importance of context-sensitive model selection. Regulatory authorities may consider integrating liquidity and operational indicators into supervisory frameworks, while insurance management can utilize multi-dimensional EWS models as proactive monitoring tools. For investors, divergence between classical and enhanced EWS scores may serve as an early-warning signal of latent financial stress.

This study is limited by its two-company, six-year design, which, while appropriate for sensitivity analysis, constrains external generalizability. Future research should extend this framework to larger samples, incorporate additional insurance segments, and develop EWS models specifically tailored to Islamic financial systems.

Ultimately, the findings demonstrate that selecting an inappropriate EWS model does not merely reduce analytical precision, but can distort risk perception and delay critical financial decision-making.

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