Final Year Design Project Showcase
Batch-2022
Year 2026

Department: Mathematics Programme: Computational Finance	
1	**Project Title** Cyber Security Risk Assessment and Insurance Pricing Modelling in Pakistan
2	**Project Idea** • This project introduces a pioneering, localized, data-driven framework that bridges the gap between technical cybersecurity exposure and financial actuarial risk management specifically for Pakistani Small and Medium Enterprises (SMEs). • Due to severe local data limitations and the complete absence of domestic underwriting models, Pakistani businesses have historically struggled to quantify cyber risks, leaving the domestic insurance sector unable to price policies accurately. • This project solves this systemic problem by converting qualitative, technical, organizational, and behavioral threat factors into an objective, standardized composite risk metric, translating it directly into fair, commercially viable insurance premiums.
3	**Process** A six-phase, dual-source methodology combining expert judgment with data-driven modeling: **1. Risk Factor Identification:** We reviewed national and international literature to shortlist 19 cyber risk factors across four categories (Technical, Human-Behavioral, Organizational, Infrastructure). **2. Data Collection:** A Delphi expert survey of 103 professionals (IT managers, cybersecurity analysts, SME owners, insurance officers, auditors) across 7 major Pakistani cities to weight each factor, supported by secondary organizational records; final dataset of 1,385 SME profiles across 21 variables. **3. Risk Scoring**: A fuzzy-logic membership model (Min-Max scaled 0–1) computes a survey-weighted Cyber Risk Score / Expected Breach Index per SME, classifying firms into Low,Medium,High & Critical bands using dynamic mean ± standard-deviation thresholds. **4. Actuarial Modeling:** a Poisson Generalized Linear Model (log-link) predicts breach

	frequency from cybersecurity controls (Pseudo $R^2 = 0.878$), combined 60/40 with an OLS regression on the fuzzy Expected Breach Index into one Combined Breach Score. **5. Loss & Premium Calculation**: Predicted breach frequency × historical loss severity gives Expected Loss per SME; a Z-score-based Tail Risk Factor (0.05–0.90) then loads the premium for catastrophic/extreme-event risk. **6. Validation:** The pricing model's discriminatory power was benchmarked with the Gini Coefficient (Model Gini 0.1568 vs Perfect Gini 0.2052 → Normalized Gini 76.42%), confirming it reliably ranks SMEs by true risk exposure and prices them accordingly.
4	**Outcome** A fully working, end-to-end Cyber Risk Assessment & Insurance Pricing framework for Pakistani SMEs that: • **Standardized Scoring System:** Successfully developed a composite Cyber Risk Score (CRS) that maps organizations into dynamic risk bands (Low, Medium, High, Critical) using standard deviation boundaries around the population mean. • **High Predictive Power:** The Poisson GLM achieved exceptional model fit with a Pseudo-R square of **87.80%** and a remarkably low Root Mean Squared Error (RMSE) of **0.3687**, establishing robust predictability. • **Actuarial Pricing Engine:** Created a localized premium calculator that uses the Collective Risk Model to output baseline expected financial losses. • **Capital Protection System:** Integrated a conditional piecewise tail-risk adjustment using Z-scores to accurately load premiums against extreme, low-frequency, high-severity cyber catastrophes (such as large-scale ransomware), protecting underwriting solvency. • **Empirical Validation:** Validated premium structures via Lorenz integration, yielding an exceptionally high Normalized Gini Coefficient that proves strong discriminatory power in ranking enterprise risks
5	**Evidence (Theoretical Basis)** Pakistan faces a rapidly growing cyber threat landscape with no standardized framework to assess organizational cyber risk or price cyber insurance, leaving SMEs unaware of their exposure and insurers unable to underwrite policies confidently • **Research Gap:** a gap confirmed across the literature (Khan & Anwar, 2020; Ahmed & Malik, 2019; Hussain & Javed, 2020). This project builds on established actuarial theory. Generalized Linear Models for frequency-severity insurance rating (Goldburd, Khare & Tevet, 2025), Extreme Value Theory and Tail Value-at-Risk for catastrophic-loss modeling (Embrechts, Klüppelberg & Mikosch, 2013), fuzzy-logic treatment of qualitative risk indicators (Fakhravar, 2020; Xu, Li & Wang, 2024), and Delphi-based expert elicitation and localizes it using primary data from 103 Pakistani cybersecurity/insurance experts and a 1,385-record SME dataset.

	• Total technical, organizational, human-behavioral and infrastructure risk factors are combined into a Cyber Risk Score via fuzzy weighting, translated into breach-frequency predictions via a Poisson GLM and OLS regression, and converted into a Z-score-adjusted actuarial premium. • Model validation via the Gini Coefficient (76.42% normalized) shows the framework achieves industry-acceptable risk-ranking accuracy, closing the localization gap identified in prior Pakistan-specific cybersecurity research.
6	**Competitive Advantage or Unique Selling Proposition**
a	**Attainment of any SDG** 1. **SDG 9 (Industry , Innovation, and Infrastructure):** This framework fosters sustainable industrial growth by giving Pakistani SMEs a clear roadmap to measure and strengthen their digital infrastructure. By making cyber insurance accessible, it provides a crucial safety net for localized technological innovation. 2. **SDG 8 (Decent Work and Economic Growth):** Cyberattacks routinely bankrupt resource-constrained small businesses. Providing a localized risk transfer mechanism safeguards the long-term financial stability, digital operations, and business continuity of the domestic enterprise ecosystem, stabilizing economic growth
b	**Cost Reduction of Existing Product** Removes two costs at once: for insurers, the cost of mispricing cyber policies using imported developed-market models that don't reflect Pakistan's threat landscape (leading to under-reserved capital or unsellable, overpriced premiums); and for SMEs, the hidden cost of operating with zero cyber insurance, where the report's own historical data shows a single breach averaging PKR 4–13 million in losses. The Poisson-GLM-based frequency-severity engine removes the guesswork from both sides of the transaction.
c	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggests) • **The Current Issue:** Traditional underwriters use generic, international cyber-pricing models derived from advanced foreign economies. These models rely on mature regulatory environments and massive historical reporting datasets that do not exist in Pakistan, resulting in wildly inaccurate premium pricing, systemic underwriting losses, or high costs that bar SME adoption. • **Our Proposed Improvement:** This project introduces a localized multi-track framework that handles data scarcity by blending expert fuzzy logic systems with empirical regression counts. It replaces subjective industry guesswork with transparent, risk-adjusted actuarial pricing. Organizations that proactively optimize

	critical controls are instantly rewarded with lower premium rates, directly driving market-wide cybersecurity maturity. This project replaces that gap with an automated six-phase pipeline : **Factor Identification → Data collectionand Cleaning → Fuzzy Scoring → Poisson GLM & OLS breach prediction → eExpected-loss Calculation → Z-score tail-risk loading** i.e, that takes a cybersecurity questionnaire and returns a fully justified premium in one run, validated with a Pseudo R^2 of 0.878 and a Normalized Gini of 76.42%.
d	**Expanding of Market share** (e.g. how it expand and what is the problem with the current market **The Problem with the Current Market:** The domestic market penetration for commercial cyber insurance in Pakistan sits near **0%** because underwriters lack models tailored to local realities, leaving insurance portfolios stagnant. **Serviceable Obtainable Market (SOM):** High-growth, digital-first local organizations (e.g., FinTech startups, e-commerce networks, digitized supply chain logistics) that require affordable, rapid operational risk transfers to satisfy corporate partnerships and regulatory compliance. **How It Expands Market Share:** By deploying an automated underwriting API, local commercial insurers can easily integrate this pricing engine directly into customer onboarding portals. The system expands market share by providing dynamic premium incentives as SMEs optimize their controls, the engine instantly recalculates and lowers premiums, attracting a massive wave of high-growth, digital-first organizations (FinTechs, e-commerce networks, and digitized logistics firms) that require rapid risk transfers to satisfy corporate partnerships
e	**Capture New Market** (e.g. Niche market or unaddressed segment) Cyber insurance penetration in Pakistan is close to zero.The very problem this project was built to solve. By giving insurers a working, locally-validated pricing engine, the framework unlocks an essentially untapped product line (cyber insurance for SMEs) that no local insurer currently offers with actuarial rigor, positioning early adopters as first movers among Pakistan's several million registered SMEs. • **Niche Market & Unaddressed Segment:** Small and Medium Enterprises (SMEs) make up over **90% of all private economic establishments** in Pakistan and contribute roughly **40% to the national GDP**, yet they represent an entirely unaddressed, uninsured niche within the cyber risk landscape. • **Why Industry Will Invest:** International cyber insurance models require stringent certifications (like ISO 27001) that local firms cannot meet, completely locking them out. Because our engine uses a hybrid mathematical approach leveraging Fuzzy Set Theory to handle uncertified operational realities, it can successfully underwrite companies that foreign models flag as "uninsurable,"

	opening a completely untapped, high-volume domestic cyber insurance market for local insurers and InsurTech startups.	
f	**Cyber Takaful(Future enhancement)** Extend the pricing framework to support **Shariah-compliant Cyber Takaful** products, providing an alternative cyber risk transfer mechanism for organizations preferring Islamic insurance solutions.	
7	**Target Market** • **Primary Institutional End-Users:** Non-life commercial insurance companies, Takaful operators, and emerging InsurTech platforms looking to deploy mathematically verified cyber underwriting products within Pakistan. • **Regulatory Stakeholders:** Financial and digital regulatory authorities, including the Securities and Exchange Commission of Pakistan (SECP) and the Pakistan Telecommunication Authority (PTA), to support national cybersecurity reporting frameworks and standardize operational risk guidelines. • **Enterprise End-Users:** Small and Medium Enterprises (SMEs), financial tech startups, and technology providers across Pakistan seeking a clear, transparent tool to evaluate their threat posture, optimize internal security budgets, and transfer residual liabilities.	
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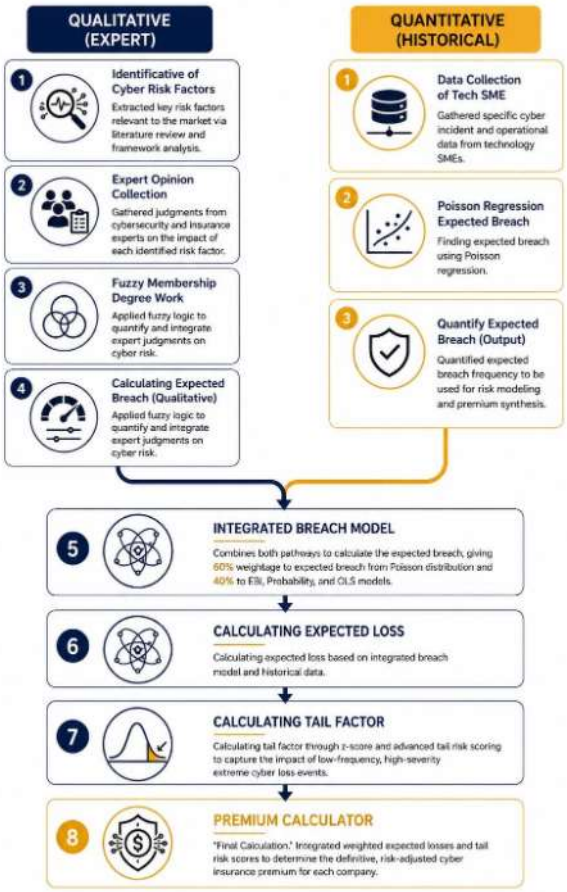

Figure 1: Structural flow of Model's Implication

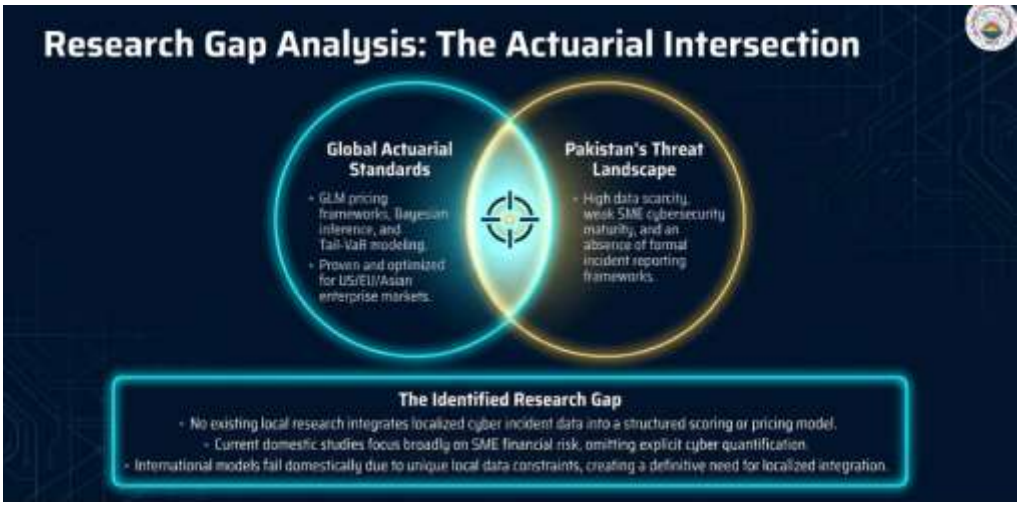

Figure 2: Research Gap Analysis

Figure 3: End-to-end Risk framework journey

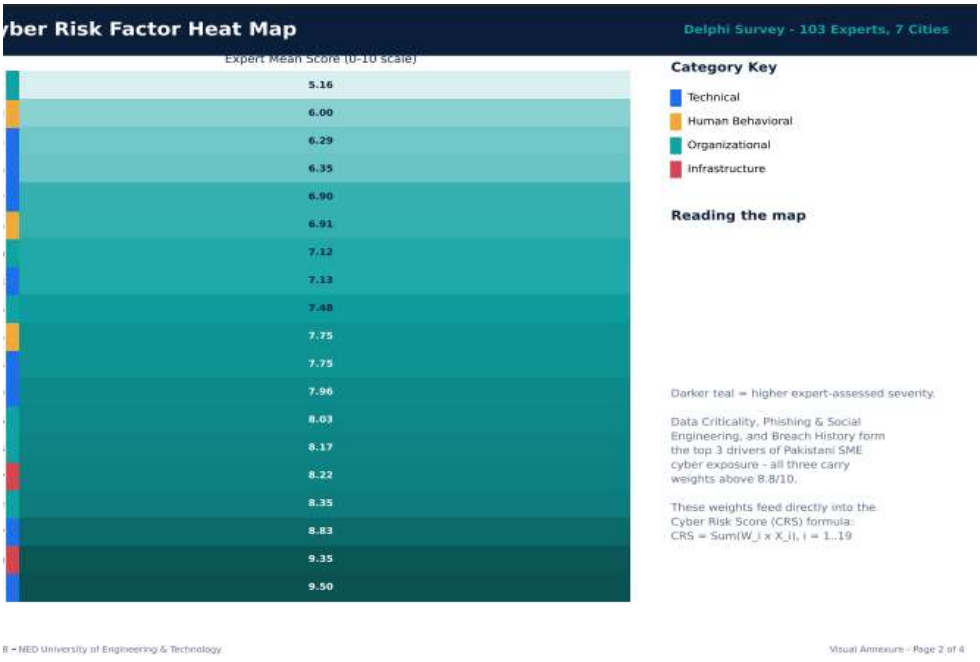

Figure 4: Cyber Risk Factor Heat Map

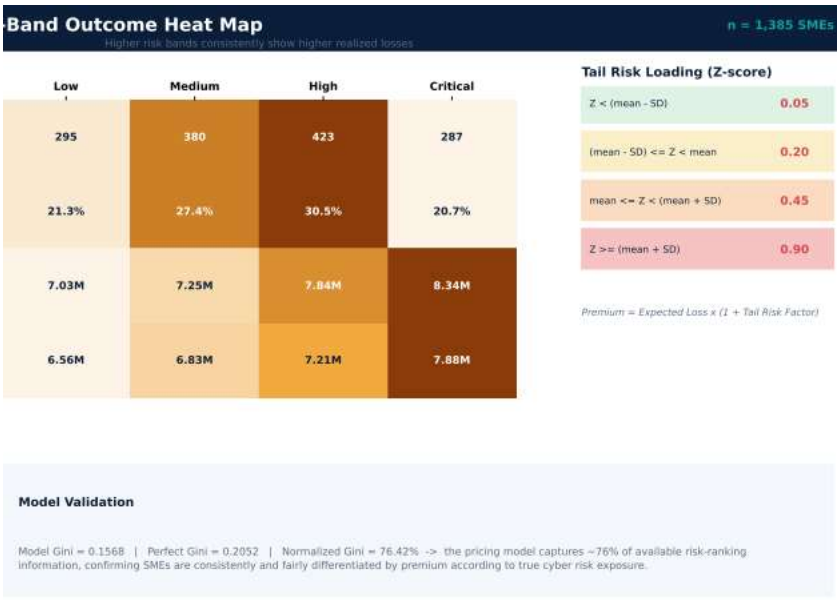

Figure 5: Risk-Band Outcome Heatmap

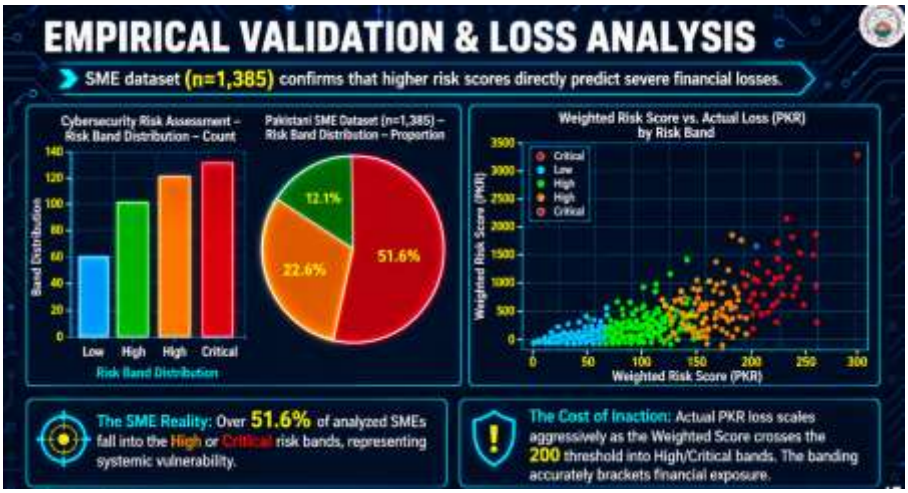

Figure 6: Empirical Validation & Loss Analysis

Figure 7: Cyber Takaful & Shariah Compliant Model