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Combining GLM and Machine Learning for Smarter Pricing

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Contents

- 01. GLM - How it works**
- 02. Replicate GLM with ML Model**
- 03. Understand key concepts behind modeling**
- 04. How Hybrid model works**
- 05. Result Exploration**

GLM: Why use it?

Familiarity and Trust

Actuaries' extensive training fosters confidence in GLMs

Industry Standard

GLMs are widely adopted as the primary modeling technique in insurance.

Interpretability

GLMs provide clear insights into risk factors and outcomes.

Regulatory Acceptance

Regulators favor GLMs for their transparency and fairness.

Statistical Soundness

GLMs are grounded in robust statistical theory.

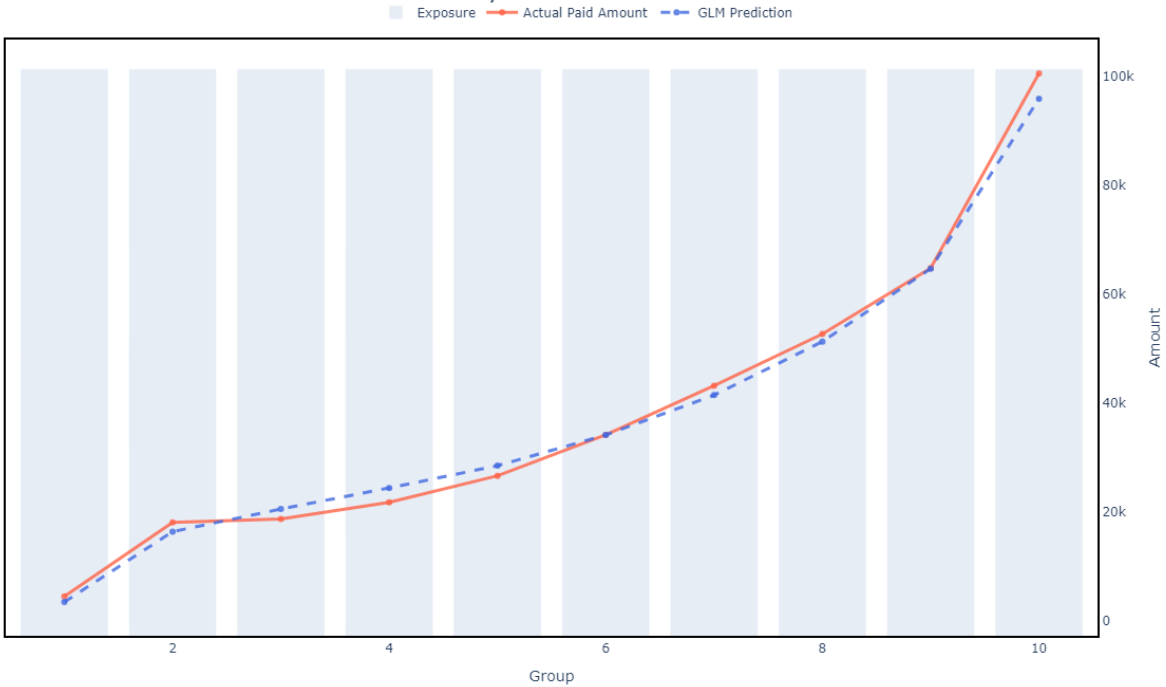


GLM: How it Works?

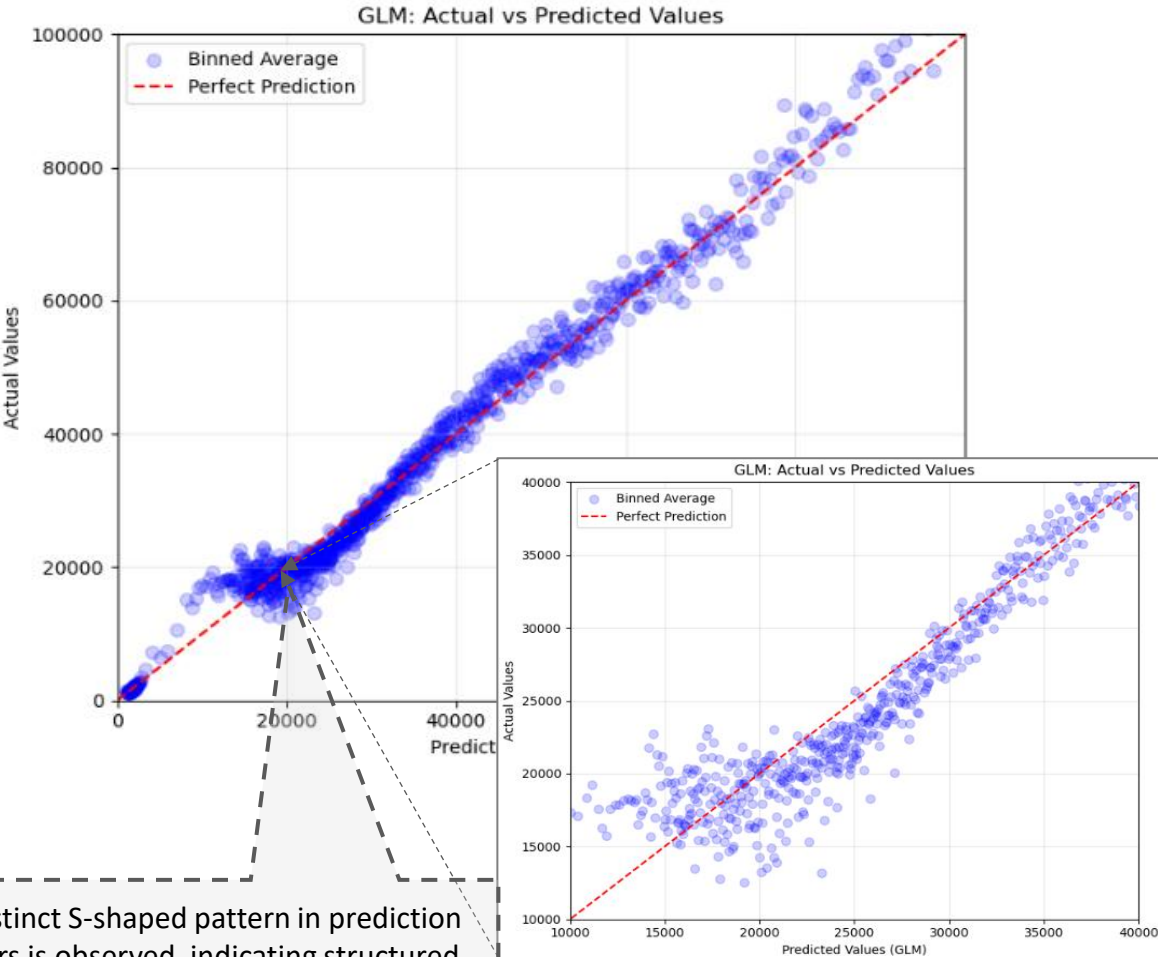


GLM Results: Health Market Data

Lift Chart Analysis: GLM Prediction vs Actual

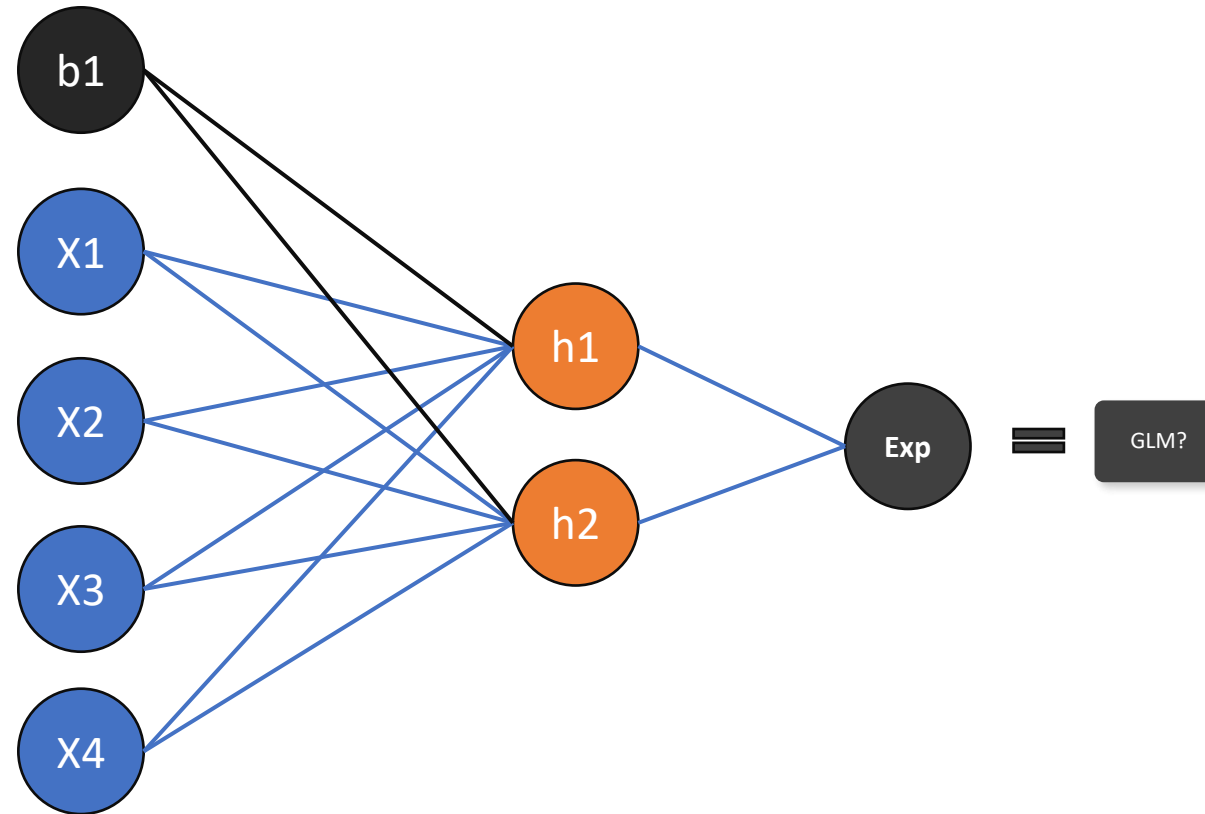


Additional Tests:
Residual Analysis, AIC, BIC, Gini Coefficient / Lorenz Curve, NLL comparison

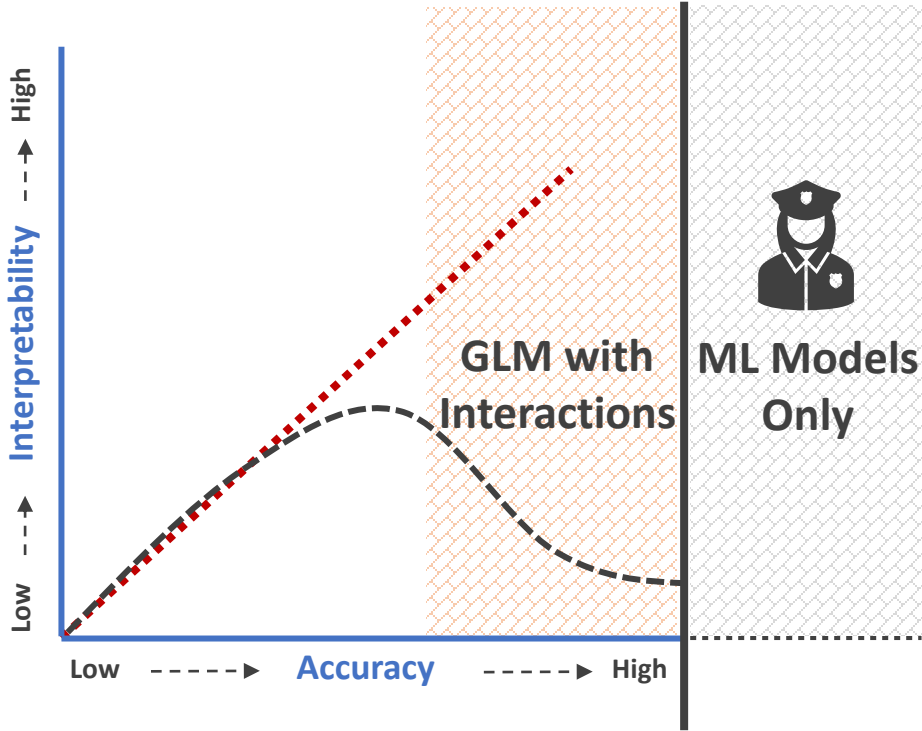


A distinct S-shaped pattern in prediction errors is observed, indicating structured deviations rather than random fluctuations.

Neural Network: GLM?



GLM or ML: ?



High Interpretability

Emphasize understanding and explaining the model's decisions, possibly sacrificing some accuracy.



How to prioritize model characteristics?

High Accuracy

Focus on achieving the best predictive performance, potentially at the cost of interpretability.

GLM Strengths

- ... Interpretability
- ... Strong predictive performance

GLM Limitations

- ... Limited interaction handling
- ... Feature engineering burden
- ... Counterintuitive relativities for complex models

Comparison of GLM and ML

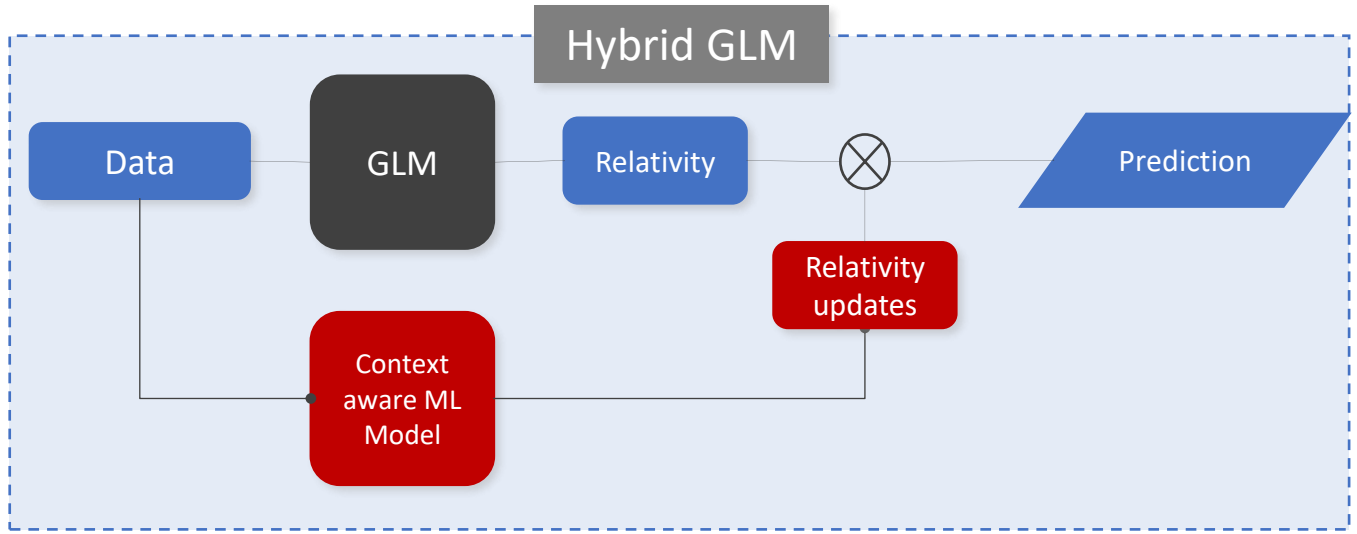
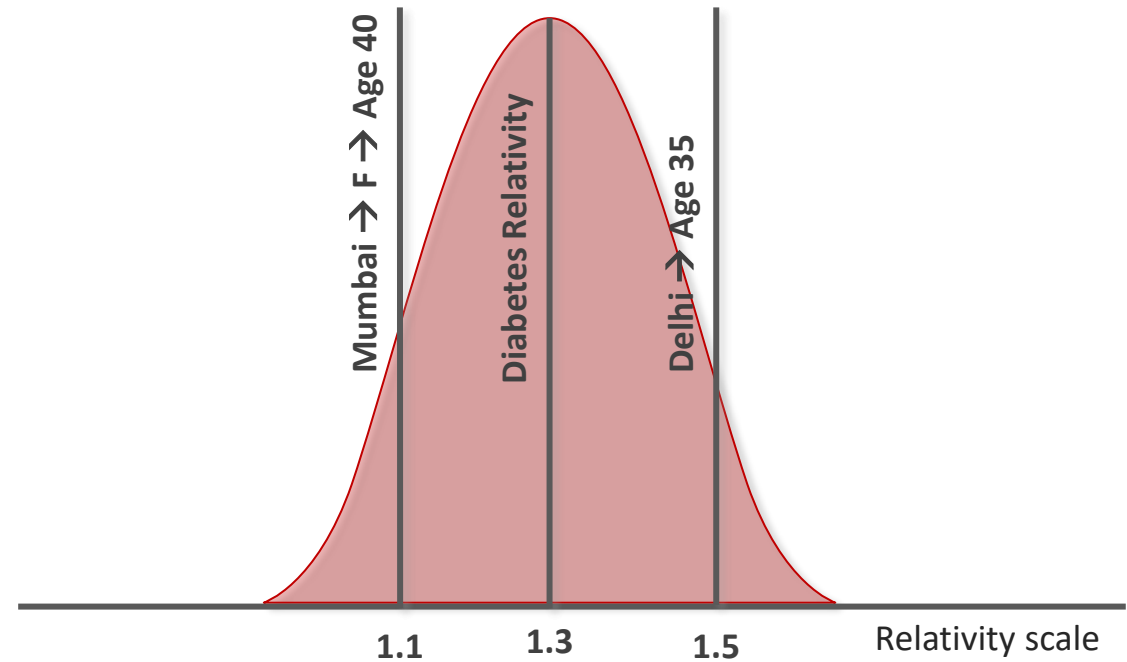
ML Strengths

- ... Non-linearity is not a constraint
- ... Automatic interaction discovery
- ... High predictive accuracy

ML Limitations

- ... Interpretability challenges
- ... Trust and Auditability concern

Hybrid GLM: How it Works



GLM

$$\mu = \text{base} \times \text{Age} \times \text{Gender} \times \text{Location}$$

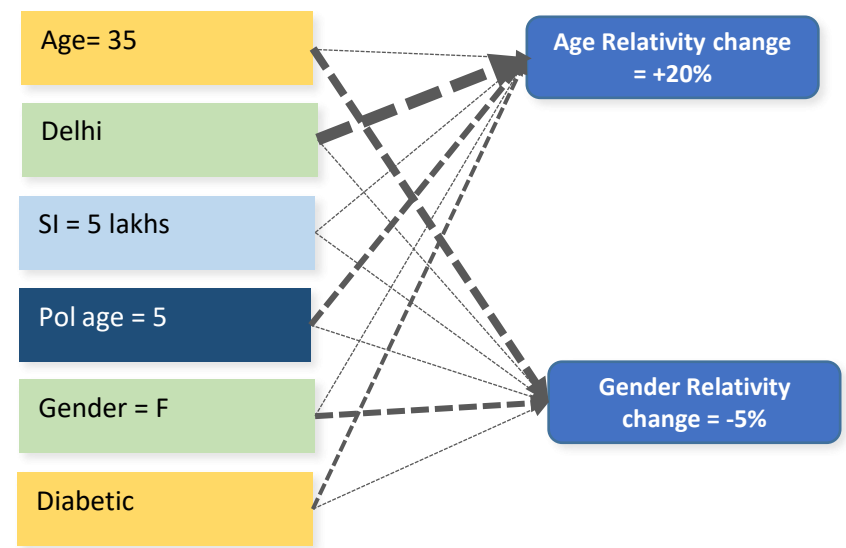
GLM Relativity

Hybrid GLM

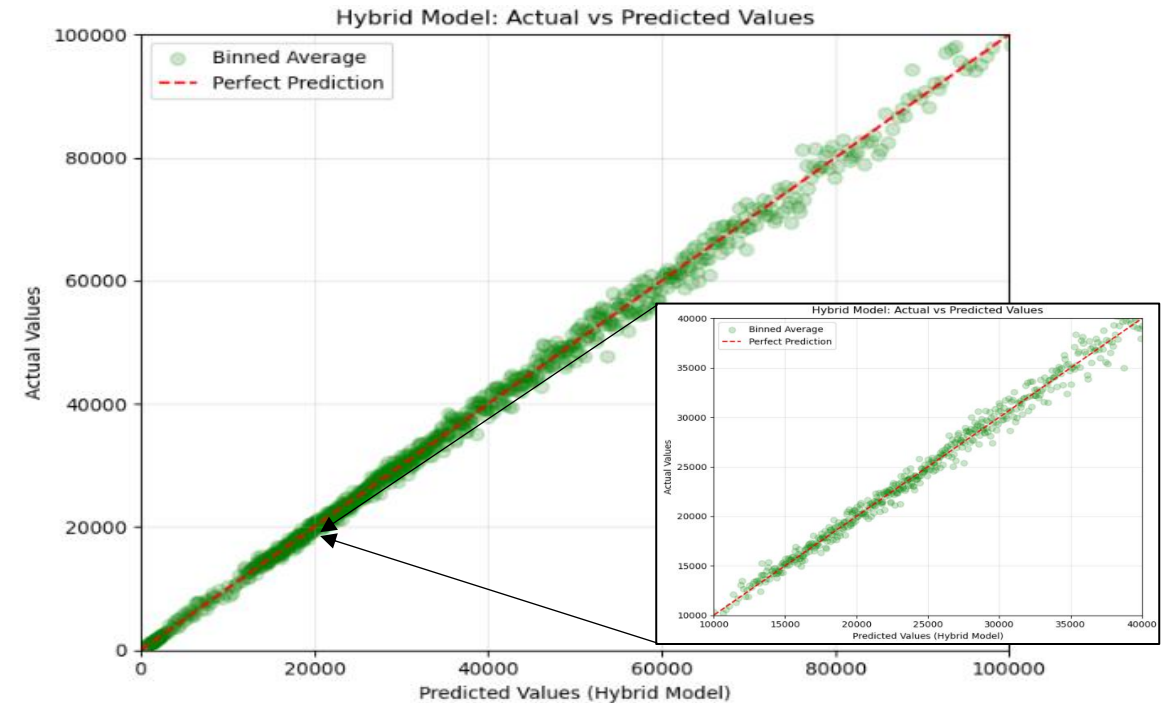
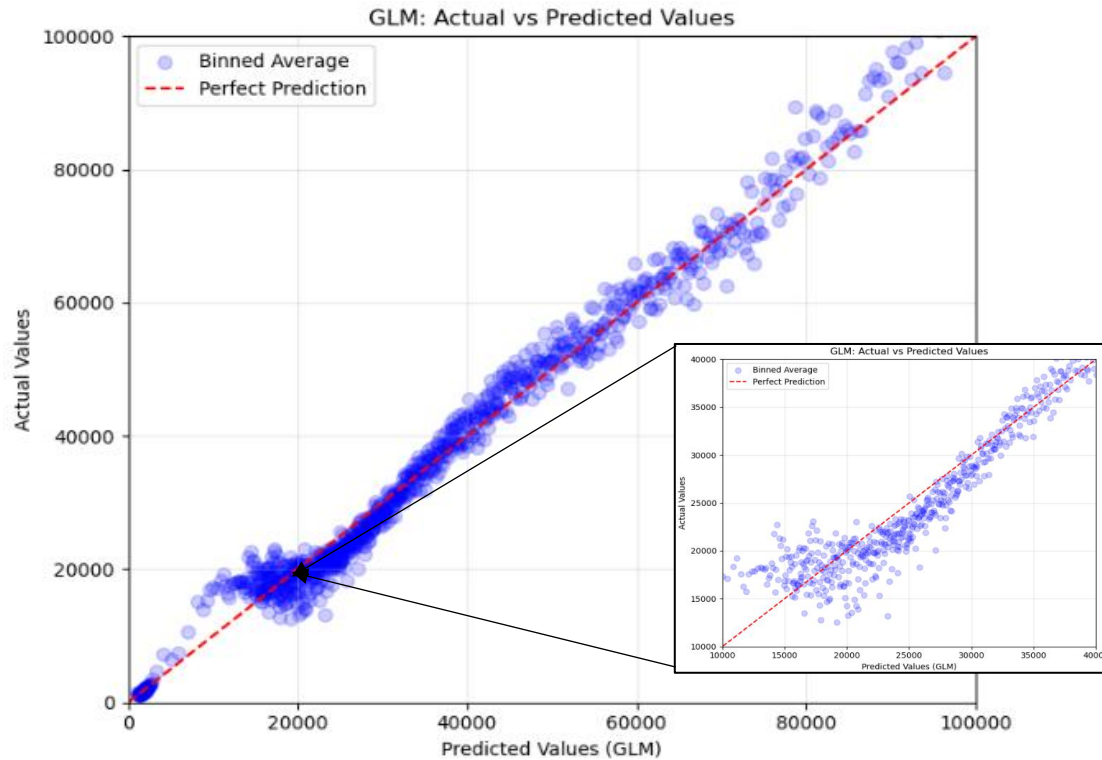
$$\mu = \text{base} \times \text{Age} \Delta \times \text{Gender} \Delta \times \text{Location} \Delta$$

Δ Context aware **change in Relativity** at individual policy level

Policy Level view



Results: Comparison with GLM



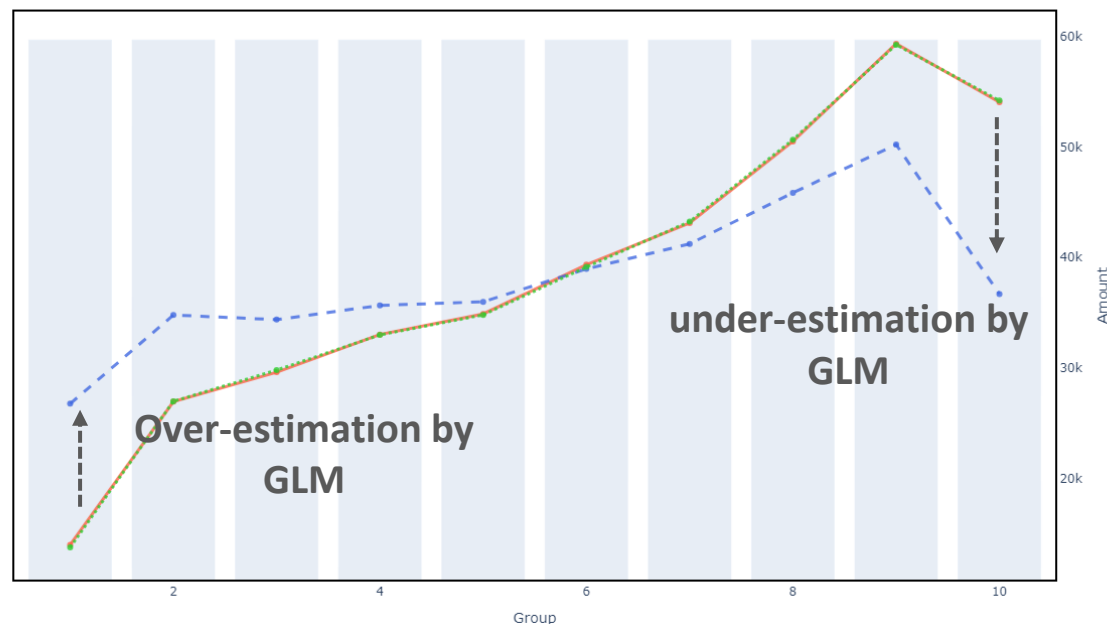
Observations:

- Hybrid model significantly reduces discrepancies between actual and expected values.
- Addresses GLM's misalignments with observed data.
- Hybrid model autonomously determines factor importance and interactions.

Results: Comparison with GLM

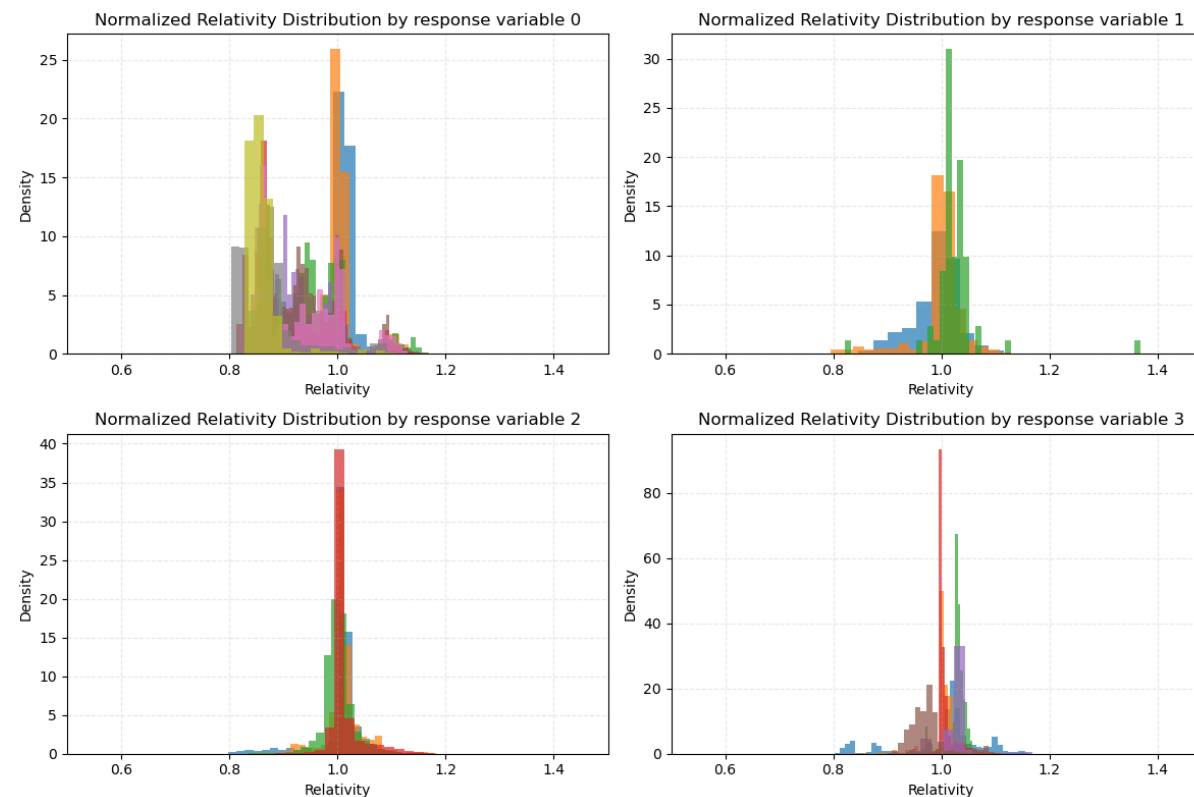
Lift Chart Analysis: GLM and Hybrid Model Predictions vs Actual

Exposure Actual Paid Amount GLM Prediction Hybrid Model Prediction



Observations:

- Hybrid model predictions align much closer with actual values.
- GLM overestimated severity nearly **2x**, which hybrid model corrects.
- Outperforms GLM in handling complex, nonlinear relationships while staying interpretable.



Observations:

- Shows adjustments proposed to each level under different context.
- Variable 0 GLM relativities requires significant corrections suggesting complex interactions with other variables.
- Variable 2 GLM relativities are well-calibrated, minimal adjustments needed

Hybrid Model: Advantages

Scalability & Continuous Evolution

The hybrid model is designed to seamlessly scale with increasing data volumes while dynamically adapting to emerging risk patterns

Enhanced Risk Assessment

ML branch refines GLM outputs, while avoiding combinatorial complexity of explicit interaction terms.



Balanced Accuracy & Interpretability

Merges GLM transparency with ML predictive power for practical insurance modeling. Majority of the target prediction is derived by the GLM model.

Strategic Flexibility

Can use GLM branch for pricing and more traditional roles; Use hybrid branch for model improvement and portfolio optimization.

Can extent this framework to unstructured data and probabilistic output to further enhance the predictive performance.



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ACTUARIAL EXCELLENCE IN THE AGE OF DISRUPTION

THANK YOU!