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Session 5

GLM and its application in general insurance

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Predictive Analytics

GLM and its application in general insurance

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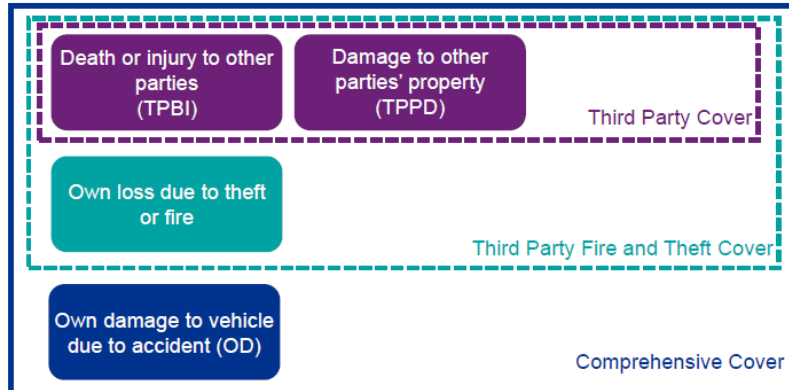


Brief Introduction of Motor Insurance Rating in Malaysia

Motor Insurance

- Malaysia case study

Motor Insurance in Malaysia is renewed yearly
 Premiums are paid before insurance coverage starts



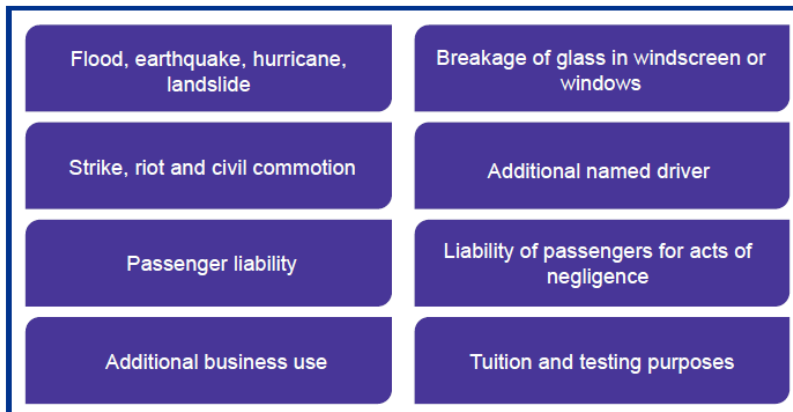
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Motor Insurance

- Extension Cover

Additional perils can be added to the policy with additional premiums



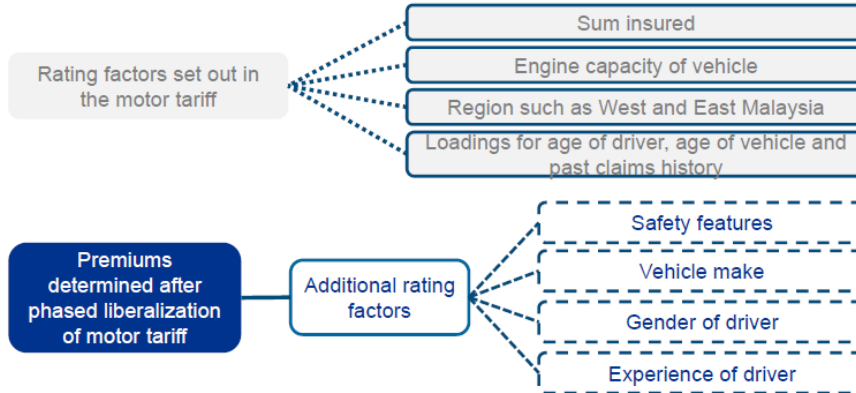
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Motor Tariff

- Rating Factors

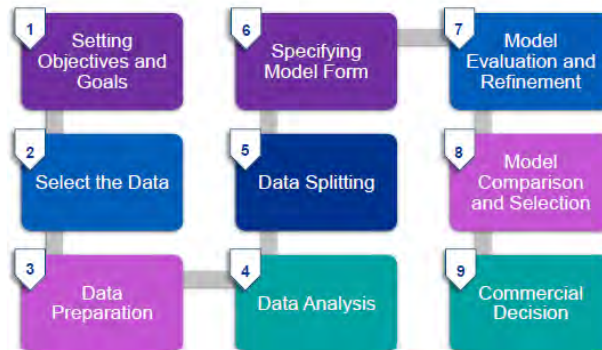
Premium rates charged by the insurance companies range within the allowable loading limit of Motor Tariff. It is a very competitive market for profitable growth.



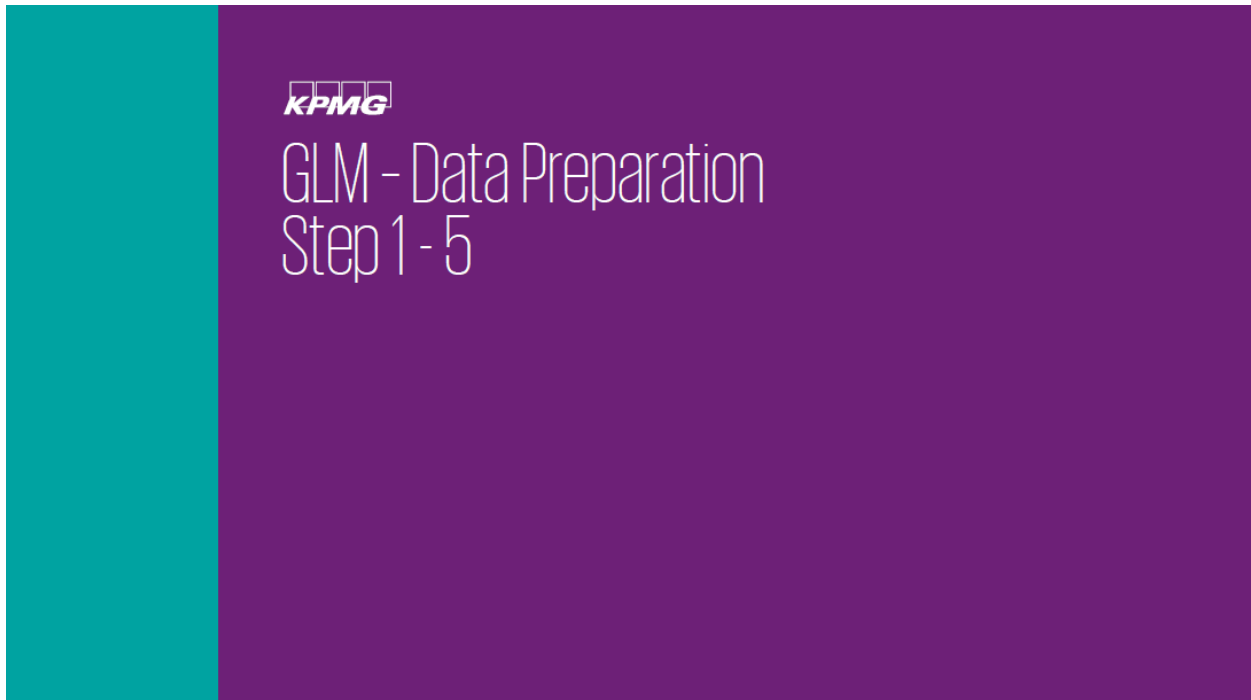
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Internal Pricing Process

A robust premium rating and governance process are required by the regulation.

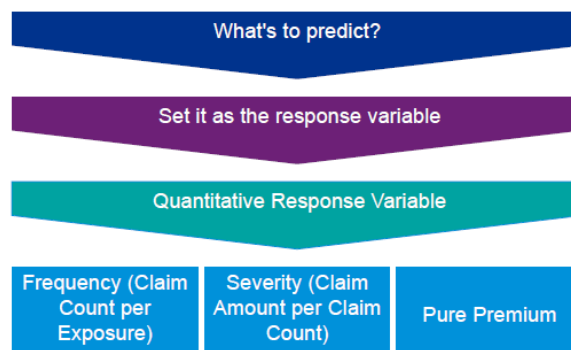


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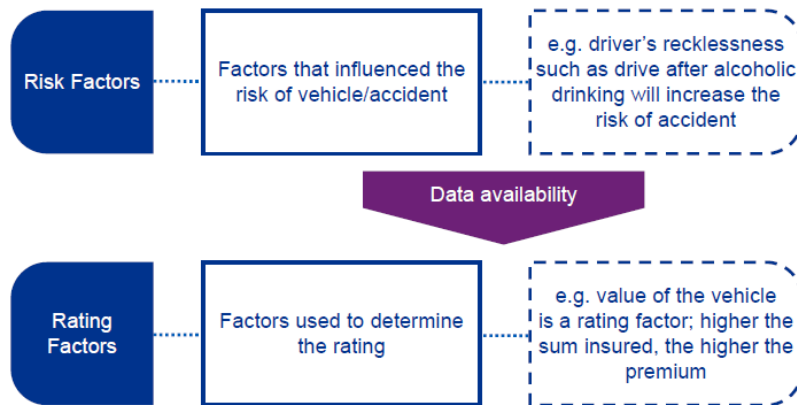
Step 1. Setting Objectives and Goals

- Purpose of Modelling



Step 2. Select the Data

- Risk Factor Vs. Rating Factor



Step 2. Select the Data (cont'd)

- Driver Factors Category

Rating Factor	Description	Data Structure
Age of Driver	Age of vehicle owner, or age of policyholder	Integer
Driving Experience	Length of driving period or Experience	Integer
Driving Record	Number of traffic offences or bad record	Integer
Gender	Male or Female	Categorical
Marital Status	Single or Married	Categorical
Number of Driver	List of drivers in the policy	Integer

Step 2. Select the Data (cont'd)

- Vehicle Factors Category

Rating Factor	Description	Data Structure
Cubic Capacity	Dimension of vehicle engine	Integer
Manufactured Year	Number of years since the vehicle is manufactured	Integer
Safety Features	Number of safety installations	Integer
Odometer	Distance travelled by the vehicle	Numerical
Vehicle Type	Sports or Normal vehicle	Categorical



Step 2. Select the Data (cont'd)

- Location Factors Category

Rating Factor	Description	Data Structure
Region	East or West Malaysia	Categorical
Address Location	Postcode	Categorical
Urbanization Level	City, rural and suburban	Categorical



Step 2. Select the Data (cont'd)

- Policy Factors Category

Rating Factor	Description	Data Structure
Sum Insured	Market value or agreed value of the vehicle	Numerical
Policy Coverage	Type of coverage	Categorical
Renewal Indicator	New business or renewal Business	Categorical
Claim Count Experience	Number of claim incurred in the past	Integer
Claim Amount Experience	Amount of claim incurred in the past	Numerical
No Claim Discount (NCD)	Discount offered for good driving record	Numerical



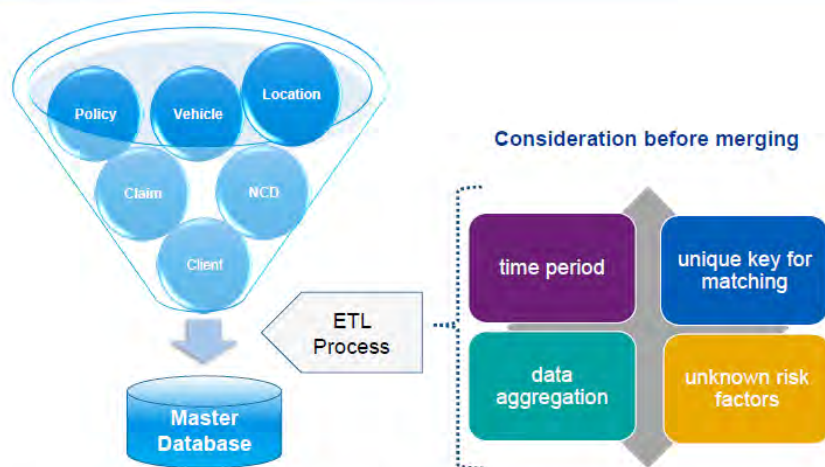
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Step 3. Data Preparation

- Merging and Consideration

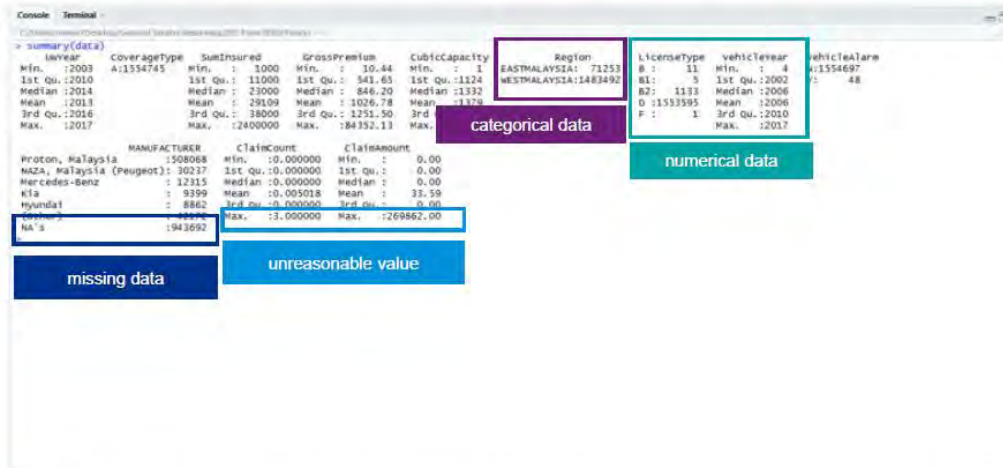


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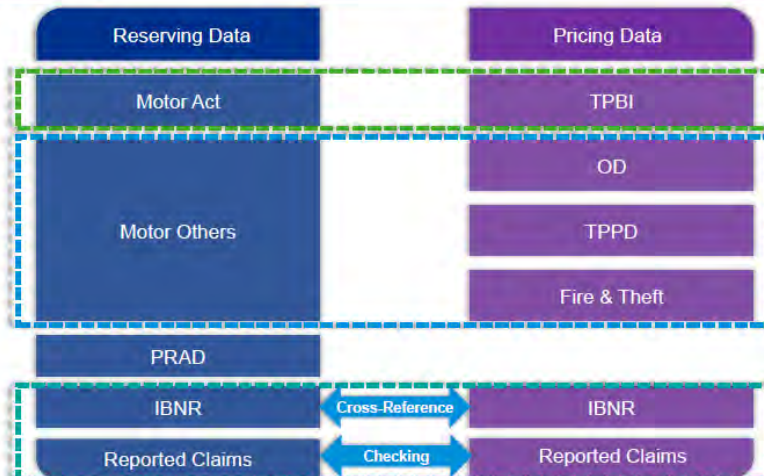
Step 3. Data Preparation (cont'd)

- Merging and Consideration



Step 4. Data Analysis

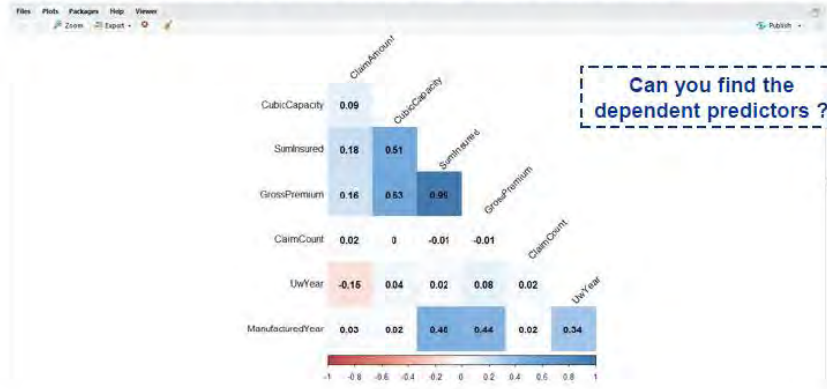
- Reserving vs Rating



Step 4. Data Analysis (cont'd)

- Correlation Plot

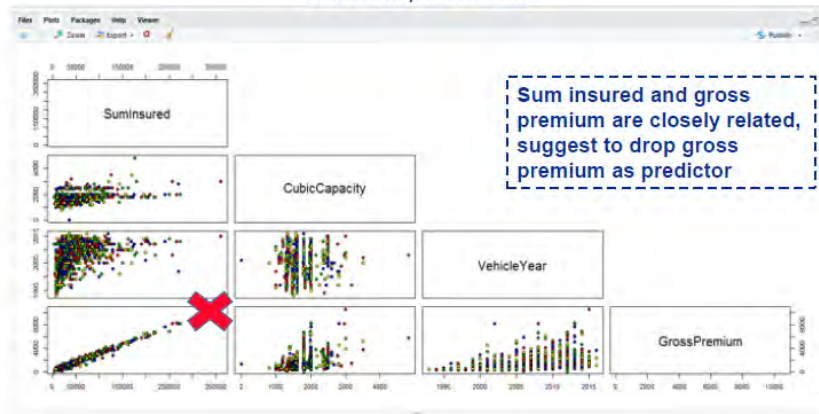
Correlation Plot – Pearson Coefficient Correlation Method



Step 4. Data Analysis (cont'd)

- Relationship Pattern Plot

Relationship Pattern Plot



Step 5. Data Splitting

- Training and Validation Sets



Generalized Linear Model

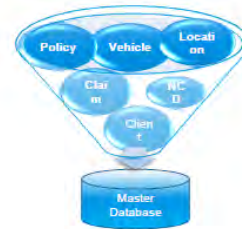
- Response variable

Regression analysis is a form predictive modeling technique which investigates the relationship between a response variable Y and the predictors X_i

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p + \varepsilon$$

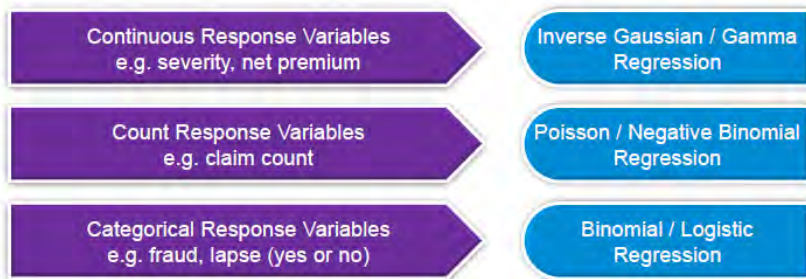
Response variable

Specifies the explanatory variables (X_1, X_2, \dots, X_N) in the model



Generalized Linear Model (cont'd)

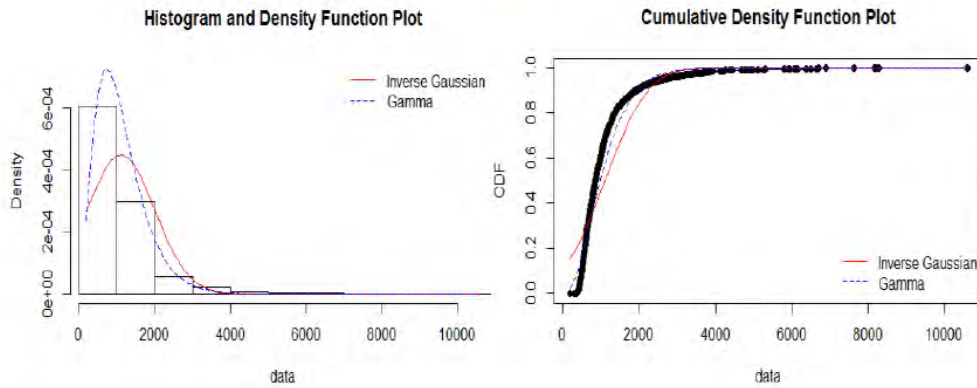
- Response variable



Generalized Linear Model (cont'd)

- Response variable

Gamma distribution v.s. Inverse Gaussian distribution for Severity Model



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Generalized Linear Model (cont'd)

- Response variable

Distribution	Typical Uses	Support of Distribution
Gaussian (Normal)	Linear response data, constant increments or decrements	Real: $(-\infty, +\infty)$
Inverse Gaussian	Positively skewed data with distribution's tail decreases slowly	Real: $(0, +\infty)$
Gamma	Exponential response data, increase or decrease with constant ratio	Real: $(0, +\infty)$

Distribution	Typical Uses	Support of Distribution
Binomial	Single outcome from N occurrences	Integer: $0, 1, 2, \dots, N$
Poisson	Count data	Integer: $0, 1, 2, \dots$



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Generalized Linear Model (cont'd)

- Link Function

The relationship between the mean of the response variable distribution function and a linear combination set of predictors

Numerical example for a Gamma Log Link Model

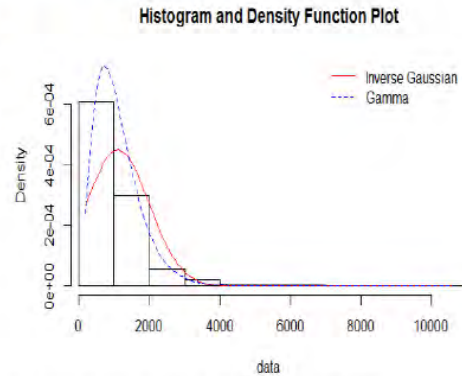
$$\ln[E(\text{Severity}_i)] = \alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p$$

$$E(\text{Severity}_i) = \text{Exp}\{\alpha + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_p X_p\}$$

$$\mu_i = E[Y_i] = E(\text{Severity}_i) = 3,000$$

$$\ln[E(\text{Severity}_i)] = \ln[3,000] = 8.01$$

$$E(\text{Severity}_i) = \text{Exp}\{8.01\} = 3,000$$



Generalized Linear Model (cont'd)

- Link Function

Distribution	Link Name	Link Function, $X\beta = g(\mu)$	Mean Function
Normal	Identity	$X\beta = \mu$	$\mu = X\beta$
Inverse Gaussian	Inverse Squared	$X\beta = \frac{1}{\mu^2}$	$\mu = (X\beta)^{-\frac{1}{2}}$
	Log	$X\beta = \ln(\mu)$	
Gamma	Inverse	$X\beta = \frac{1}{\mu}$	$\mu = -(X\beta)^{-1}$
	Log	$X\beta = \ln(\mu)$	
Binomial	Logit	$X\beta = \ln\left(\frac{\mu}{1-\mu}\right)$	$\mu = \frac{\exp(X\beta)}{1 + \exp(X\beta)}$
Poisson	Log	$X\beta = \ln(\mu)$	$\mu = \exp(X\beta)$



Generalized Linear Model (cont'd)

- Weights

In insurance, the greater risks should carry more weight in the estimation of the model coefficients

For example, the exposure for each observation is different, one observation might relate to one month's exposure, and another to one year's exposure. The analysis weights are "known" value that can vary from observation to observation.

Numerical example for a Gamma Log Link Model

$$\ln[E(\text{Severity}_i)] = \alpha + w_1X_1 + w_2X_2 + \dots + w_pX_p$$

$$E(\text{Severity}_i) = \text{Exp}\{\alpha + w_1X_1 + w_2X_2 + \dots + w_pX_p\}$$

where w is the vector of weighted model coefficients

Generalized Linear Model (cont'd)

- Offsets

When the effect of predictor is known, it is appropriate to include the information into the model as a known effect.

This can be achieved by using the "offset term", whose coefficient is constrained to be 1.

Numerical example for a Gamma Log Link Model

$$\ln[E(\text{Severity}_i)] = \alpha + \beta_1X_1 + \beta_2X_2 + \dots + \beta_pX_p + \ln(\text{offset})$$

$$E(\text{Severity}_i) = \text{Exp}\{\alpha + \beta_1X_1 + \beta_2X_2 + \dots + \beta_pX_p\} \times \text{offset}$$

Step 6. Specifying Model Form

- Severity Model Example

Training Set

Objective	Predict the Expected Severity of Motor Insurance
Response Variable	Severity = Claim Amount / Claim Count
Predictors	Sum Insured, Underwriting Year, Cubic Capacity of Vehicle, Manufacturer of Vehicle, Manufactured Year, Region
Weights	Claim Count
Models	Inverse Gaussian Distribution or Gamma Distribution
Link Function	Log Link Inverse Gaussian and Log Link Gamma



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Step 7. Model Evaluation and Refinement

- Goodness of Fit Test

Training Set

Measurements	Conditions / Formula
Log-Likelihood	$l_{null} \leq l_{model} \leq l_{saturated}$
Deviance	$Deviance = 2 \times (l_{saturated} - l_{null})$
Akaike Information Criterion (AIC)	$AIC = -2(\log\text{-likelihood}) + 2(n_{parameter})$
Akaike Information Criterion Corrected (AICc)	$AICc = AIC + \frac{2k^2 + 2k}{n - k - 1}$
Bayesian Information Criterion (BIC)	$AIC = -2(\log\text{-likelihood}) + k \times \log(n)$



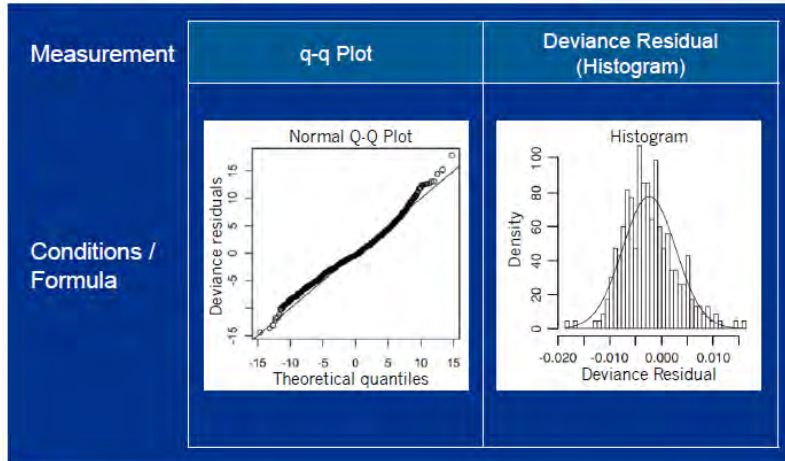
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Step 7. Model Evaluation and Refinement

- Goodness of Fit Test (Cont'd)

Training Set



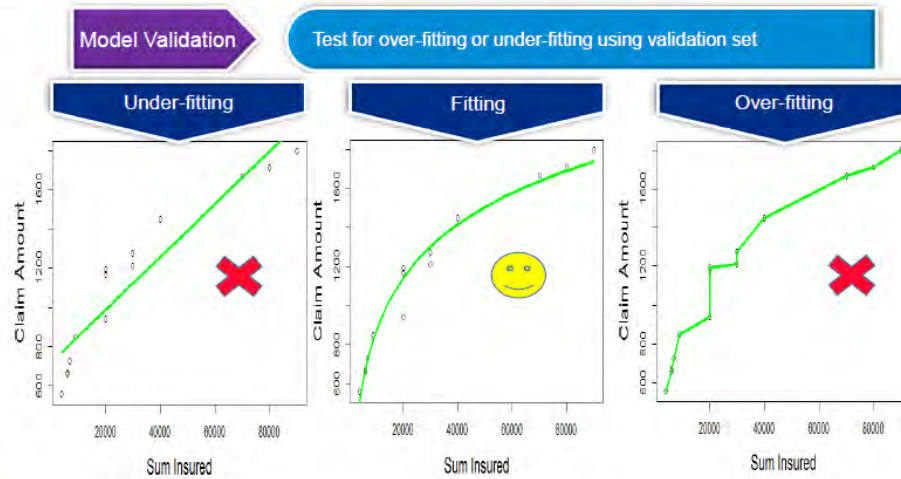
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Step 7. Model Evaluation and Refinement

- Other Evaluation Criteria

Training Set



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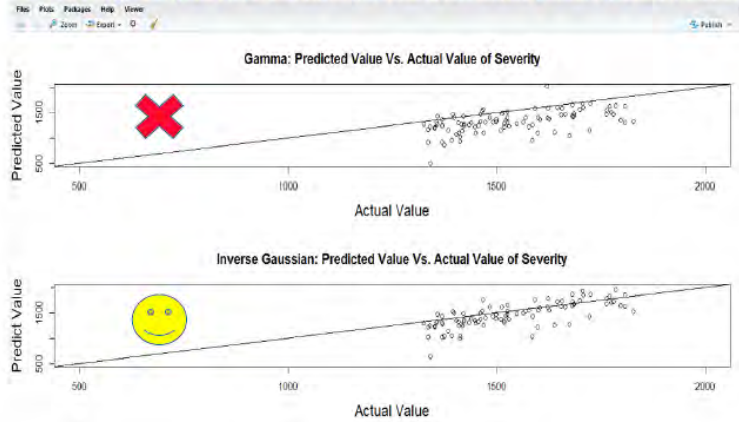
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Step 8. Models Comparison and Selection

- Comparing Models

Test Set

Assessing with plot of the Actual vs. Predicted Value to select a final model

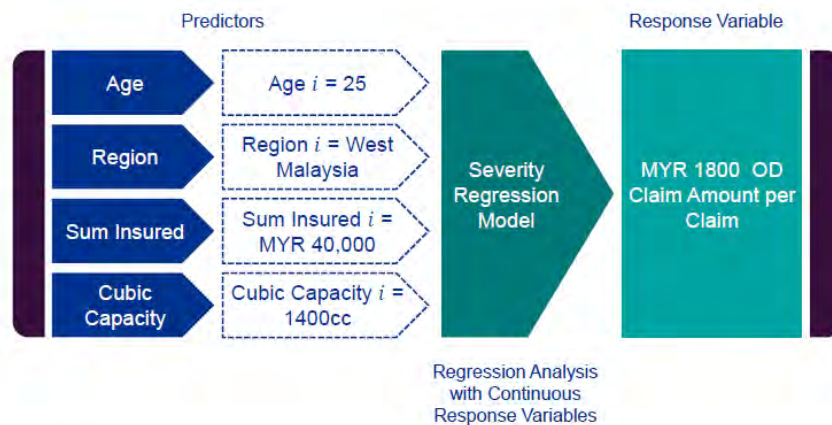


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Step 8. Models Comparison and Selection

- Final Model

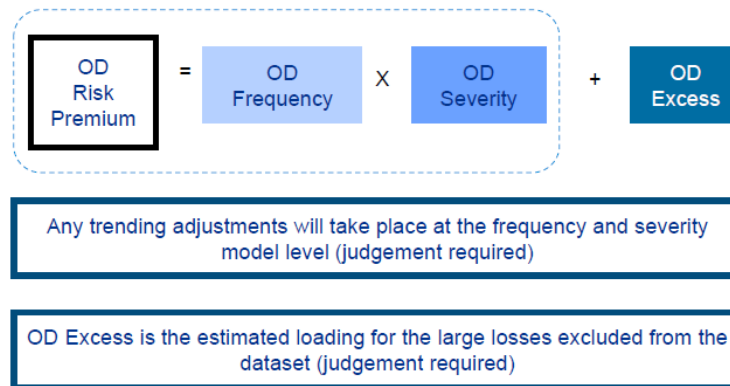


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Step 8. Models Comparison and Selection

- Final Model (cont'd)



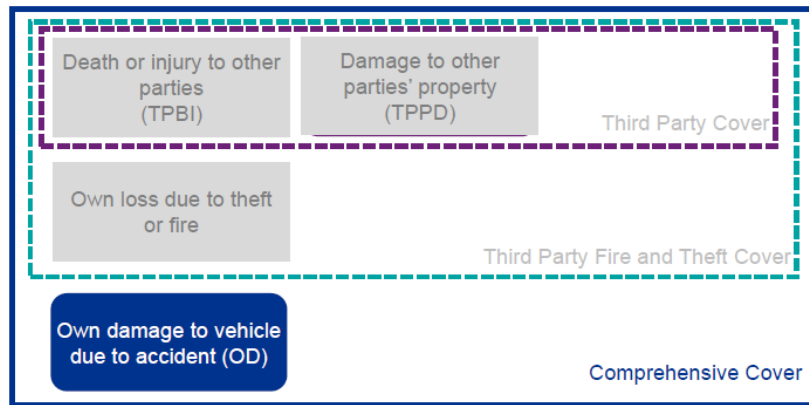
Step 8. Models Comparison and Selection

- Net Rating



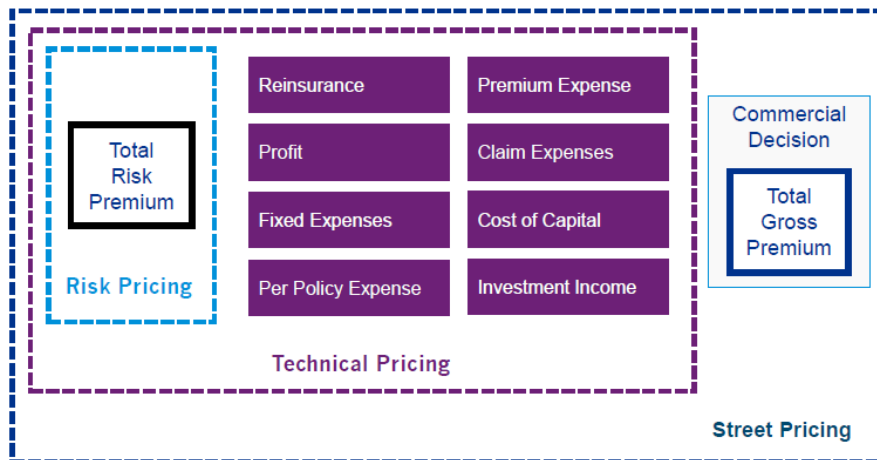
Step 9. Commercial Decision

- Malaysia case study



Step 9. Commercial Decision

- Gross Rating





Thank you

Questions





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