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Predictive Model Checklists Introduction

Regulators frequently using the NAIC rate model review service have asked the NAIC rate model review team to create a list of rate filing documentation needed for the NAIC to complete a full-scope rate model review. The checklists below refer to "new model" vs. "model refresh." A "model refresh" is a model where a prior iteration of the model was already filed with the department of insurance requesting review and the latest iteration uses the same data sources, variables, and modeling assumptions (model type, error distribution assumptions, etc.) as the prior iteration. A model which does not meet this definition of a model refresh is considered a new model.

The goals of the NAIC model checklists are to make the NAIC review of models process more efficient and expeditious. Regulators may evaluate these lists and determine the state's needs. Regulators can share this list with insurers, revise the state's rate filing checklists, or communicate with insurers through rate filing objections, when needed.

The lists below are divided into "Essential Information" and "Sometimes Needed Information." These terms are defined in this table:

Category	**Description**
Essential Information	Information that the NAIC rate model review team requests before writing a full-scope initial assessment of a model.
Sometimes Needed Information	Information that the NAIC model review team finds useful for model reviews but may only be needed if something appears non-standard about the modeling approach. Regulators may want to wait to request such information from insurers only when requested in the initial NAIC report.

This document is meant to address multiple model types. There are some differences in model documentation available for different model types. The sections below are divided by model type. Today, the majority of predictive models used in personal automobile and home insurance rating plans are GLMs. According to many in the insurance industry, GLMs introduce significant improvements over univariate-based rating plans by automatically adjusting for correlations among input variables. Tree-based models, including random forests and gradient boosting machines, can capture complex non-linear relationships between predictor variables and the target variable. Tree-based models can account for deep interactions between predictor variables. Penalized regression methods can mitigate the risk of overfitting and multi-collinearity in a multi-variate model. Some penalized regression methods (such as lasso regression) also offer automatic variable selection. This checklist document details the rate filing documentation requested by the NAIC Model Review Team for efficient review of standard GLMs, Tree-based models, and penalized regression models.

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Generalized Linear Model (GLM) List

GLM Introduction

Essential Information

- A narrative discussing what the company is trying to accomplish with the model, including the following details:
    - Is this a new model or refresh? What is the prior model's SERFF number (if applicable)?
    - Does the filing impact existing renewals?
    - What is the target market for the product?
    - What is the target variable of the model? (Frequency, Severity, Loss Ratios, Pure Premium, etc.) How is it defined?
    - What is being optimized? Does the model consider anything other than differences in loss cost?
- A narrative discussing the specifications and high-level assumptions of the model, including the following details:
    - Number of GLMs
    - Split of the data into models (by coverage, by peril, etc.)
    - Split of the data into datasets (training, test, holdout)
    - How models were combined to derive the final rating algorithm

Sometimes Needed Information

- A narrative discussing the credentials of the lead modeler and actuary reviewing the model (if applicable), including the following details:
    - Name of each individual
    - Relevant educational experience
    - Relevant credentials and designations
    - Years of experience building predictive models
    - Years of experience in the insurance industry
- Discuss how Actuarial Standards of Practice (ASOPs) 12, 23, 41, and 56 were considered in building the models.
- Describe the software (including packages and libraries if applicable) used to build the models.
- Provide copies of or links to academic references for their modeling techniques.
- A table listing the states where the model has been filed for review, the SERFF tracking number, and an indicator showing whether the filing has been approved.

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GLM Data

Essential Information

- A narrative providing the description of each data source including the following:
  - Informational materials or website links for each 3rd party
  - Commentary on how the company reviewed the veracity of the data source
  - Why the company believes the data source is useful for the model's intended purpose
  - Disclosure of known data errors
  - The filing number representing the latest prior iteration of the model which contains the same proposed third-party data variables (if applicable).
- A description of the relevance of the data
  - The lines of business and companies included should be identified
  - Description of any considerations or adjustments made to make the data more applicable for its intended use
- A data dictionary provided as a table with the following columns:
  - Data Source (Vendor name or "Internal")
  - Variable name
  - Alternate names appearing in other filing documents
  - Data types (discrete, continuous, logical, categorical)
  - Treatment Type (Model, Control, Offset, Target)
  - Possible values (Empirical min and max for numerical variables, all categories for categorical variables)
- Tables showing summary metrics for each dataset (training, testing, holdout) by year, when applicable
  - Year
  - Losses
  - Exposures (or Policy Count)
  - Claim Count (if applicable)
- A narrative on how the company determined the variables to include in the final model
- A narrative on the data accuracy and data reconciliation process
  - Description of the methods used to compile, filter, and/or merge data from different sources
  - How the data was reconciled to other sources
- A listing of the rational explanation for each modeled variable that discusses why it would plausibly impact insurance risk as discussed in the CASTF white paper.
- A guarantee that the modeling dataset will be retained for at least 7 years.
- A description of any dimensionality reduction techniques (PCA, clustering, etc.) that were applied to the data.

Sometimes Needed Information

- A description of steps taken to meet state requirements regarding unfair discrimination (if applicable).
- A listing of variables which are subject to the fair credit reporting act (if applicable).
- The percentage of data coming from the state where the model is filed for each dataset (training, testing, holdout).
- A listing of variables initially considered but later removed from the model.
- An Excel file with 10 anonymized sample modeling records including all predictor variables and target variables.

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GLM Modeling

Essential Information

- A narrative discussing the specifications and assumptions of the model, including the following details:
    - Form of the regression equation
    - Distribution assumed for the error term
    - The link function
    - Weights used in regression (if applicable)
- A description of how the model differs from prior versions of the model (if applicable).
- A narrative on the steps taken to eliminate the effects of other rating plan variables from the model (e.g. offsets).
- A description for each control or offset variable, regarding why it was necessary to treat them as control/offset variables.
- A description of how the variables with null or missing values will be treated, including the following:
    - A table showing the rate of null or missing values for each variable
    - A description of the scenarios which generated null or missing values
    - A description of how each null or missing value is treated (might include imputation method or simply left in as a control)
    - A description of what happens to null and/or missing values when generated in production. (Is there a rating factor applied for null/missing or is the data populated before policy issuance?)
- A description of any large loss capping applicable to the dataset
    - Identify the size of the large loss cap
    - Identify the percentile of claim severity represented by large loss cap
- A description of adjustments and modifications to the data including trending, loss development, capping at minimums or maximums, and removal of outliers.
- A description of variable transformations applied to the data. The description should include the name of each transformation technique used, and an example transformation complete with a sample unadjusted value and a final transformed value.
- A description of each feature engineered variables. The description should include the rationale behind the feature engineered variable and a sample calculation including unadjusted original variable values and the final feature engineered variable value.
- A description of how binning was applied to numeric variables and how categorical variable values were grouped together.

Sometimes Needed Information

- Deviance residual plots for each model demonstrating the appropriateness of the model assumptions.

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GLM Validation

Essential Information

- A narrative on how the model was validated and assessed for model stability
- A narrative on how the model was assessed for improvement over the prior version of the model (if applicable)
- Provide a demonstration of each variable's statistical significance, via at least one of the following ways:
    - GLM output with beta coefficients and corresponding p-values
    - AIC analysis comparing the full model AIC versus each subset model excluding one variable at a time
    - F nested model tests comparing the full model to subset models excluding one variable at a time
    - Double lift charts comparing the full model versus each subset model excluding one variable at a time
    - Error analysis showing that the full model error is lower on a test dataset than each subset model excluding one variable at a time
- Decile plots (quantile plots with at least 10 buckets) for both state specific data and countrywide data, built on data not used for model training. Each plot should include lines for both predicted averages and actual averages.
- Lorenz curve for each model built on countrywide data. The plot should include the Lorenz curve and the equality reference line. The plot should also include the Gini value for the model.
- An Excel file containing correlation matrices in this format:
    - Each model's correlation matrix is a separate worksheet
    - Row 1 and Column 1 include variable names
    - The rest of the table displays the correlation metrics
- Commentary on which correlation metric (Pearson's, Cramer's V, etc.) was provided in the correlation matrix Excel file

Sometimes Needed Information

- A description of how often the model will be validated against new data in the future.
- A double lift chart comparing the newly proposed model and the current model (if applicable)
- Actual vs. Expected plots by model and variable (aka "Univariate Plots") which show the closeness between actual averages and predicted averages.
- Variance Inflation Factors (VIFs) for each variable

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GLM Implementation

Essential Information

- A description of how the models being filed are ultimately integrated into the company's final rating algorithm
- A narrative about all post modeling adjustments, such as smoothing, mapping to scores, and tempering of factors
- A narrative identifying the risk classes where deviations from indicated were made and commentary on the reason for the deviations
- A dislocation analysis accounting for all rate changes within the filing, including the following:
    - Histograms showing percentage premium change on uncapped and capped basis (if applicable), using buckets of 5%
    - Descriptions of the scenarios with the highest increases
    - Descriptions of the scenarios with the biggest decreases
- Commentary on the differences between rating new and existing policyholders
- An Excel file which documents deviations between indicated and selected in this format:
    - Each model is a separate worksheet
    - Column A is Risk Class
    - Column B is the Current Factor (if applicable)
    - Column C is the Indicated Factor
    - Column D is the Proposed Factor
    - Column E is the percentage difference between indicated and proposed. If the absolute value of the percentage difference is > 10%, the cell should be highlighted.
- Sample rating/scoring exhibits for 10 risks in Excel, which show risk characteristics, all intermediate adjustments, and the final algorithm output considering the company's final selections.

Sometimes Needed Information

- Description of how the results of the model will be displayed or explained to policyholders.

Tree-based Model (Random Forest, GBM, etc.) Checklist

Tree-based Model Introduction

Essential Information

- A narrative discussing what the company is trying to accomplish with the model, including the following details:
    - Is this a new model or refresh? What is the prior model's SERFF number (if applicable)?
    - Does the filing impact existing renewals?
    - What is the target market for the product? What is the target variable of the model? (Frequency, Severity, Loss Ratios, Pure Premium, etc.) How is it defined?
    - Does the model consider anything other than differences in loss cost?
- A narrative discussing the specifications and high-level assumptions of the model, including the following details:
    - Number and type of models (GBM, Random Forest, etc.)
    - Split of the data into models (by coverage, by peril, etc.)
    - Split of the data into datasets (training, test, holdout)
    - How models were combined to derive the final rating algorithm

Sometimes Needed Information

- A narrative discussing the credentials of the lead modeler and actuary reviewing the model (if applicable), including the following details:
    - Name of each individual
    - Relevant educational experience
    - Relevant credentials and designations
    - Years of experience building models
    - Years of experience in the insurance industry
- Discuss how Actuarial Standards of Practice (ASOPs) 12, 23, 41, and 56 were considered in building the models.
- Describe the software (including packages and libraries if applicable) used to build the models.
- Provide copies of or links to academic references for their modeling techniques.
- A table listing the states where the model has been filed for review, the SERFF tracking number, and an indicator showing whether the filing has been approved.

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Tree-based Model Data

Essential Information

- A narrative providing the description of each data source including the following:
    - Informational materials or website links for each 3rd party
    - Commentary on how the company reviewed the veracity of the data source
    - Why the company believes the data source is useful for the model's intended purpose
    - Disclosure of known data errors
    - The SERFF filing number representing the latest prior iteration of the model which contains the same proposed third-party data variables (if applicable).
- A description of the relevance of the data
    - The lines of business and companies included should be identified
    - Description of any considerations or adjustments made to make the data more applicable for its intended use
- A data dictionary provided as a table with the following columns:
    - Data Source (Vendor name or "Internal")
    - Variable name
    - Alternate names appearing in other filing documents
    - Data types (discrete, continuous, logical, categorical)
    - Treatment Type (Model, Control, Offset, Target)
    - Possible values (Empirical min and max for numerical variables, all categories for categorical variables)
- Tables showing summary metrics for each dataset by year (training, testing, holdout), when applicable
    - Year
    - Losses
    - Exposures (or Policy Count)
    - Claim Count (if applicable)
- A narrative on the candidate variable selection process prior to the model building.
- A narrative on the data accuracy and data reconciliation process
    - Description of the methods used to compile, filter, and/or merge data from different sources
    - How the data was reconciled to other sources
- A listing of the rational explanation for each modeled variable that discusses why it would plausibly impact insurance risk as discussed in the CASTF white paper.
- A guarantee that the modeling dataset will be retained for at least 7 years
- A description of any dimensionality reduction techniques (PCA, clustering, etc.) that were applied to the data.

Sometimes Needed Information

- A description of steps taken to meet state requirements regarding unfair discrimination (if applicable).
- A listing of variables which are subject to the fair credit reporting act (if applicable).
- The percentage of data coming from the state where the model is filed for each dataset (training, testing, holdout).
- A listing of variables initially considered but later removed from the model.
- An Excel file with 10 anonymized sample modeling records including all predictor variables and target variables.

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Tree-based Modeling

Essential Information

- A narrative discussing the specifications and assumptions of the model, including the following details:
    - Form of the regression equation (if applicable)
    - Distribution assumed for the error term (if applicable)
    - The link function (if applicable)
    - Weights used in regression (if applicable)
    - Description of the tuning procedure for all hyperparameters
    - Description of how the component trees are combined to arrive at final predictions
- A description of all hyperparameters, including the following:
    - Number of component trees
    - Number of features considered at each split in the trees
    - Sampling size (number of rows)
    - Maximum tree depth
    - Minimum volume of data per node
    - "Shrinkage" or learning rate (applicable to GBMs)
- A description of how the model differs from prior versions of the model (if applicable).
- A narrative on the steps taken to eliminate the effects of other rating plan variables from the model (e.g. offsets).
- A description for each control or offset variable, regarding why it was necessary to treat them as control/offset variables.
- A description of how the variables with null or missing values will be treated, including the following:
    - A table showing the rate of null or missing values for each variable
    - A description of the scenarios which generated null or missing values
    - A description of how each null or missing value is treated (might include imputation method or simply left in as a control)
    - A description of what happens to null and/or missing values when generated in production. (Is there a rating factor applied for null/missing or is the data populated before policy issuance?)
    - A description of how the Tree-based model treats null or missing values.
- A description of any large loss capping applicable to the dataset
    - Identify the size of the large loss cap
    - Identify the percentile of claim severity represented by large loss cap
- A description of adjustments and modifications to the data including trending, loss development, capping at minimums or maximums, and removal of outliers.
- A description of variable transformations applied to the data. The description should include the name of each transformation technique used and an example transformation complete with a sample unadjusted value and a final transformed value.
- A description of each feature engineered variables. The description should include the rationale behind the feature engineered variable and a sample calculation including unadjusted original variable values and the final feature engineered variable value.
- A description of how binning was applied to numeric variables and how categorical variable values were grouped together (if binning or grouping were applied before running the Tree-based model).

Sometimes Needed Information

- Deviance residual plots for each model demonstrating the appropriateness of the model assumptions.

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Tree-based Model Validation

Essential Information

- A narrative on how the model was validated and assessed for model stability
- A narrative on how the model was assessed for improvement over the prior version of the model (if applicable)
- Decile plots (quantile plots with at least 10 buckets) for both state specific data and countrywide data, built on data not used for model training. Each plot should include lines for both predicted averages and actual averages.
- Lorenz curve for each model built on countrywide data. The plot should include the Lorenz curve and the equality reference line. The plot should also include the Gini value for the model.
- Plots useful for understanding the model
    - Plots showing model performance by number of trees. The company should provide a plot showing that an error metric (deviance, negative log-likelihood, etc.) decreases after each iteration (each additional tree). If the company chooses an error metric other than deviance or log-likelihood, the company should describe why they chose a different metric and explain how it is calculated.
    - Variable Importance Plots highlighting which variables contributed most to the model. Provide commentary on why variables with relatively lower importance are still included in the proposed model.
    - Interpretability plots visualizing the relationship between each predictor variable and the target variable such as partial dependence plots (PDPs), accumulated local effects (ALE) plots, or Shapley plots. There should be at least one plot for every variable used in the model. The plots should be accompanied by commentary on why the visualized relationships are reasonable.
- An Excel file containing correlation matrices in this format:
    - Each model's correlation matrix is a separate worksheet
    - Row 1 and Column 1 include variable names
    - The rest of the table displays the correlation metrics
- Commentary on which correlation metric (Pearson's, Cramer's V, etc.) was provided in the correlation matrix Excel file

Sometimes Needed Information

- A description of how often the model will be validated against new data in the future
- A double lift chart comparing the newly proposed model and the current model (if applicable)
- Actual vs. Expected plots by model and variable (aka "Univariate Plots") which show the closeness between actual averages and predicted averages.

Tree-based Model Implementation

Essential Information

- A description of how the models being filed are ultimately integrated into the company's final rating algorithm
- A narrative about all post modeling adjustments, such as smoothing, mapping to scores, and tempering of factors
- A narrative identifying the variables where deviations from indicated were made and commentary on the reason for the deviations
- Tree diagrams for the first tree in each model, demonstrating how the splitting works.
- A dislocation analysis accounting for all rate changes within the filing, including the following:
    - Histograms showing percentage premium change on uncapped and capped basis (if applicable), using buckets of 5%
    - Descriptions of the scenarios with the highest increases
    - Descriptions of the scenarios with the biggest decreases
- Commentary on the differences between rating new and existing policyholders
- Documentation on deviations between indicated and selected factors, if applicable. For example, a tree-based model might assign policies to different tiers. Additional analysis after the tree model may derive indicated factors by tier. Any deviations from indicated should be disclosed.
- Sample rating/scoring exhibits for 10 risks in Excel, which show risk characteristics, all intermediate adjustments, and the final algorithm output considering the company's final selections.

Sometimes Needed Information

- Description of how the results of the model will be displayed or explained to policyholders.
- Complete documentation that would allow future audits of model predictions. This could be satisfied by one of the following:
    - Comprehensive Tree diagrams for every tree
    - Comprehensive splitting rules that reproduce the tree logic
    - Tables showing every possible combination of risk characteristics and the final model prediction.

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Penalized Regression Model (GAM, Elastic Net, Lasso, Ridge, Derivative Lasso, Lasso Credibility, etc.) Checklist

Penalized Regression Model Introduction

Essential Information

- A narrative discussing what the company is trying to accomplish with the model, including the following details:
    - Is this a new model or refresh? What is the prior model's SERFF number (if applicable)?
    - Does the filing impact existing renewals?
    - What is the target market for the product? What is the target variable of the model? (Frequency, Severity, Loss Ratios, Pure Premium, etc.) How is it defined?
    - What is being optimized? Does the model consider anything other than differences in loss cost?
- A narrative discussing the specifications and high-level assumptions of the model, including the following details:
    - Number and type of models (GAM, Elastic Net, Lasso, Ridge, Derivative Lasso, Lasso Credibility, etc.)
    - Split of the data into models (by coverage, by peril, etc.)
    - Split of the data into datasets (training, test, holdout)
    - How models were combined to derive the final rating algorithm

Sometimes Needed Information

- A narrative discussing the credentials of the lead modeler and actuary reviewing the model (if applicable), including the following details:
    - Name of each individual
    - Relevant educational experience
    - Relevant credentials and designations
    - Years of experience building models
    - Years of experience in the insurance industry
- Discuss how Actuarial Standards of Practice (ASOPs) 12, 23, 41, and 56 were considered in building the models.
- Describe the software (including packages and libraries if applicable) used to build the models.
- Provide copies of or links to academic references for their modeling techniques.
- A table listing the states where the model has been filed for review, the SERFF tracking number, and an indicator showing whether the filing has been approved.

Penalized Regression Model Data

Essential Information

- A narrative providing the description of each data source including the following:
    - Informational materials or website links for each 3rd party
    - Commentary on how the company reviewed the veracity of the data source
    - Why the company believes the data source is useful for the model's intended purpose
    - Disclosure of known data errors
    - The SERFF filing number representing the latest prior iteration of the model which contains the same proposed third-party data variables (if applicable).
- A description of the relevance of the data
    - The lines of business and companies included should be identified
    - Description of any considerations or adjustments made to make the data more applicable for its intended use
- A data dictionary provided as a table with the following columns:
    - Data Source (Vendor name or "Internal")
    - Variable name
    - Alternate names appearing in other filing documents
    - Data types (discrete, continuous, logical, categorical)
    - Treatment Type (Model, Control, Offset, Target)
    - Possible values (Empirical min and max for numerical variables, all categories for categorical variables)
- Tables showing summary metrics for each dataset (training, testing, holdout) by year, when applicable
    - Year
    - Losses
    - Exposures (or Policy Count)
    - Claim Count (if applicable)
- A narrative on how the company determined the variables to include in the final model
- A narrative on the data accuracy and data reconciliation process
    - Description of the methods used to compile, filter, and/or merge data from different sources
    - How the data was reconciled to other sources
- A listing of the rational explanation for each modeled variable that discusses why it would plausibly impact insurance risk as discussed in the CASTF white paper.
- A guarantee that the modeling dataset will be retained for at least 7 years
- A description of any dimensionality reduction techniques (PCA, clustering, etc.) that were applied to the data.

Sometimes Needed Information

- A description of steps taken to meet state requirements regarding unfair discrimination (if applicable).
- A listing of variables which are subject to the fair credit reporting act (if applicable).
- The percentage of data coming from the state where the model is filed for each dataset (training, testing, holdout).
- A listing of variables initially considered but later removed from the model.
- An Excel file with 10 anonymized sample modeling records including all predictor variables and target variables.

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Penalized Regression Modeling

Essential Information

- A narrative discussing the specifications and assumptions of the model, including the following details:
    - Form of the regression equation
    - Description of the penalty term used in fitting the model
    - Distribution assumed for the error term
    - The link function (if applicable)
    - Weights used in regression (if applicable)
- A description of the following hyperparameters
    - The penalty parameter value and how it was chosen.
    - Any other hyperparameters used in model fitting if applicable (example: number of knots for a smoothed term in a GAM). Describe how they were chosen.
- A description of how the model differs from prior versions of the model (if applicable).
- A narrative on the steps taken to eliminate the effects of other rating plan variables from the model (e.g. offsets).
- A description for each control or offset variable, regarding why it was necessary to treat them as control/offset variables.
- A description of how the variables with null or missing values will be treated, including the following:
    - A table showing the rate of null or missing values for each variable
    - A description of the scenarios which generated null or missing values
    - A description of how each null or missing value is treated (might include imputation method or simply left in as a control)
    - A description of what happens to null and/or missing values when generated in production. (Is there a rating factor applied for null/missing or is the data populated before policy issuance?)
- A description of any large loss capping applicable to the dataset
    - Identify the size of the large loss cap
    - Identify the percentile of claim severity represented by large loss cap
- A description of adjustments and modifications to the data including trending, loss development, capping at minimums or maximums, and removal of outliers.
- A description of variable transformations applied to the data. The description should include the name of each transformation technique used and an example transformation complete with a sample unadjusted value and a final transformed value.
- A description of each feature engineered variables. The description should include the rationale behind the feature engineered variable and a sample calculation including unadjusted original variable values and the final feature engineered variable value.
- A description of how binning was applied to numeric variables and how categorical variable values were grouped together.

Sometimes Needed Information

- Deviance residual plots for each model demonstrating the appropriateness of the model assumptions.
- Demonstration of how the model would differ if different hyperparameters were selected. This could take one of the following forms:
    - Sensitivity showing coefficient outputs side-by-side for higher and lower complexity hyperparameters
    - Plots showing coefficients by penalty value

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Penalized Regression Model Validation

Essential Information

- A narrative on how the model was validated and assessed for model stability
- A narrative on how the model was assessed for improvement over the prior version of the model (if applicable)
- An Excel file containing model output in this format:
    - Each model is a separate worksheet
    - Column A is Variable Name
    - Column B is Variable Level Name
    - Column C is the coefficient
- A demonstration of parameter stability via one of the following methods
    - Confidence intervals (5th to 95th percentile) of coefficients based on 100+ bootstrap samples
    - Range of coefficients from 10 or 20 cross validation folds
    - Range of coefficients across at least 5 different time periods
    - P-values from a reference GLM with the same selected variables
- Decile plots (quantile plots with at least 10 buckets) for both state specific data and countrywide data, built on data not used for model training. Each plot should include lines for both predicted averages and actual averages.
- Lorenz curve for each model built on countrywide data. The plot should include the Lorenz curve and the equality reference line. The plot should also include the Gini value for the model.
- Models with a complement of credibility (example: lasso credibility) should provide plots by variable that visualize the credibility complement and the model indicated as separate lines.
- Commentary on which correlation metric (Pearson's, Cramer's V, etc.) was provided in the correlation matrix Excel file
- Tables showing concurvity metrics (applicable to GAMs)

Sometimes Needed Information

- An Excel file containing correlation matrices in this format:
    - Each model's correlation matrix is a separate worksheet
    - Row 1 and Column 1 include variable names
    - The rest of the table displays the correlation metrics
- A description of how often the model will be validated against new data in the future
- A double lift chart comparing the newly proposed model and the current model (if applicable)
- Actual vs. Expected plots by model and variable (aka "Univariate Plots") which show the closeness between actual averages and predicted averages.

Penalized Regression Model Implementation

Essential Information

- A description of how the models being filed are ultimately integrated into the company's final rating algorithm
- A narrative about all post modeling adjustments, such as smoothing, mapping to scores, and tempering of factors
- A narrative identifying the risk classes where deviations from indicated were made and commentary on the reason for the deviations
- A dislocation analysis accounting for all rate changes within the filing, including the following:
    - Histograms showing percentage premium change on uncapped and capped basis (if applicable), using buckets of 5%
    - Descriptions of the scenarios with the highest increases
    - Descriptions of the scenarios with the biggest decreases
- Commentary on the differences between rating new and existing policyholders
- An Excel file which documents deviations between indicated and selected in this format:
    - Each model is a separate worksheet
    - Column A is Risk Class
    - Column B is the Current Factor (if applicable)
    - Column C is the Indicated Factor
    - Column D is the Proposed Factor
    - Column E is the percentage difference between indicated and proposed. If the absolute value of the percentage difference is > 10%, the cell should be highlighted.
- Sample rating/scoring exhibits for 10 risks in Excel, which show risk characteristics, all intermediate adjustments, and the final algorithm output considering the company's final selections.

Sometimes Needed Information

- Description of how the results of the model will be displayed or explained to policyholders.

Neural Network Checklist

Neural Network Model Introduction

Essential Information

- A narrative discussing what the company is trying to accomplish with the model, including the following details:
    - Is this a new model or refresh? What is the prior model's SERFF number (if applicable)?
    - Does the filing impact existing renewals?
    - What is the target market for the product? What is the target variable of the model? How is it defined?
    - What is being optimized? Does the model consider anything other than differences in loss cost?
- A narrative discussing the specifications and high-level assumptions of the model, including the following details:
    - Number and type of models (Neural Network, etc.)
    - Split of the data into models (by coverage, by peril, etc.)
    - Split of the data into datasets (training, test, holdout)
    - How models were combined to derive the final rating algorithm

Sometimes Needed Information

- A narrative discussing the credentials of the lead modeler and actuary reviewing the model (if applicable), including the following details:
    - Name of each individual
    - Relevant educational experience
    - Relevant credentials and designations
    - Years of experience building predictive models
    - Years of experience in the insurance industry
- Discuss how Actuarial Standards of Practice (ASOPs) 12, 23, 41, and 56 were considered in building the models.
- Describe the software (including packages and libraries if applicable) used to build the models.
- Provide copies of or links to academic references for their modeling techniques.
- A table listing the states where the model has been filed for review, the SERFF tracking number, and an indicator showing whether the filing has been approved.

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Neural Network Model Data

Essential Information

- A narrative providing a description of each data source including the following:
  - Informational materials or website links for each 3rd party
  - Commentary on how the company reviewed the veracity of the data source
  - Why the company believes the data source is useful for the model's intended purpose
  - Disclosure of known data errors
  - The SERFF filing number representing the latest prior iteration of the model which contains the same proposed third-party data variables (if applicable).
- A description of the relevance of the data
  - The lines of business and companies included should be identified
  - Description of any considerations or adjustments made to make the data more applicable for its intended use
- Tables showing summary metrics for each dataset (training, testing, holdout) by year, when applicable
  - Year
  - Losses
  - Exposures (or Policy Count)
  - Claim Count (if applicable)
- A narrative on the data accuracy and data reconciliation process
  - Description of the methods used to compile, filter, and/or merge data from different sources
  - How the data was reconciled to other sources
- A guarantee that the modeling dataset will be retained for at least 7 years
- A description of any dimensionality reduction techniques (PCA, clustering, etc.) that were applied to the data.
- If the neural network is trained on image data
  - Describe the team creating the initial labels, how they determined the labels, the number of people labeling each image, and what their rate of consensus was (aka interrater reliability).
  - Explain what season(s) of the year the images are captured
  - Explain what percentage of US properties have an image in the current database
  - Explain how the images are captured
  - Describe how frequently the images are refreshed
  - Describe what image quality criteria is placed on images
  - Provide a distribution of images by state for each dataset (training, testing, holdout).
  - Provide a histogram showing the age of the latest image for each dwelling in the database

Sometimes Needed Information

- A description of steps taken to meet state requirements regarding unfair discrimination (if applicable).
- A listing of variables which are subject to the fair credit reporting act (if applicable).
- The percentage of data coming from the state where the model is filed for each dataset (training, testing, holdout).

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Neural Network Modeling

Essential Information

- A narrative discussing the specifications and assumptions of the model, including how the hyperparameters of the neural networks were tuned.
- Provide the hyperparameters selected for the neural network, including the following:
    - Learning Rate
    - Number of Epochs
    - Batch Size
    - Activation Function
    - Number of hidden layers and units
    - Weight initialization
- A description of how the model differs from prior versions of the model (if applicable).
- Commentary on how the risk of overfitting was mitigated including whether these common methods were applied:
    - Early Stopping
    - Regularization
    - Dropout
- Provide plots that help demonstrate how the models work
    - For Artificial Neural Networks (ANN), provide Shapley plots by variable
    - For Artificial Neural Networks (ANN), provide waterfall plots for:
        - 10 records with the worst score and commentary on what is driving the score
        - 10 records of false positives (if applicable) and commentary on what is driving misclassification
        - 10 records of false negatives (if applicable) and commentary on what is driving misclassification
    - For Convolutional Neural Networks (CNN), provide Grad-CAM images for:
        - 10 images with the worst score and commentary on what is driving the score
        - 10 images of false positives (if applicable) and commentary on what is driving misclassification
        - 10 images of false negatives (if applicable) and commentary on what is driving misclassification

Sometimes Needed Information

- A description of any preprocessing (resizing, normalization, etc.) applied to the images before running the model.

Neural Network Model Validation

Essential Information

- A narrative on how the model was validated and assessed for model stability
- A narrative on how the model was assessed for improvement over the prior version of the model (if applicable)
- A confusion matrix for the Test and/or Holdout datasets arranged as follows:
    - Predicted Class in the row names
    - Actual Class in the column names
    - Test Dataset count in the table
- A summary of performance metrics (precision, recall, accuracy) on the test dataset.
- 10 sample images including model predictions and actual values.
- A description whether the model predictions were compared to an independent report (example: roof image classification versus findings from an actual roof inspection)

Neural Network Model Implementation

Essential Information

- A description of how the models being filed are ultimately utilized by the company
- An explanation regarding whether the data source used to train the model is the same data source that will be used in production. If not, what adjustments will be made to address differences between data sources.
- An explanation regarding whether the neural network prediction can be reproduced by a person using an objective criteria checklist
- A description regarding how consumers can appeal determinations made by the neural network
- A description of how often the data will be refreshed, whether scores will be updated automatically, and whether consumers can request an update to the score
- If the neural network is trained on image data
    - Explain whether an insured can personally submit an updated image if there have been updates to their property

Sometimes Needed Information

- Description of how the results of the model will be displayed or explained to policyholders.