

Using the Hayne MLE Models: A Practitioner's Guide Model Instructions

In the “Hayne MLE Practitioners Guide.zip” file you will find all of the files described in the Supplementary Materials section of the “Using the Hayne MLE Models: A Practitioner's Guide” paper. The primary Hayne MLE modeling files you can use to review the full details of the calculations of the modeling framework are:

1. Model Instructions.pdf (this PDF document)
2. Industry Data.xls (Schedule P data as of 12/31/08)
3. Hayne MLE Models.xlsm
4. Best Estimate.xlsm
5. Aggregate Estimate.xlsm
6. Correlation Ranks.xlsm

The last four Excel files contain the Hayne MLE models described in the paper. Reading the paper will guide you when exploring the educational content of the model files, but not all of the issues and model variations discussed in the paper are reproduced in these Excel files.

Note: The models require Excel 2010 or later to run.

All of the sheets in each file are protected (without a password) to maintain the integrity of the calculations, but the unprotected data entry cells are noted in **blue**. You may unprotect the sheets to review the calculations, but you may not use a password when protecting the sheets again as this will cause an error in the routines. You must set the Macro Security level low enough to enable macros before any of these files are opened. The Hayne MLE Models file is set up to run a 10 x 10 triangle or less, but NO larger size. All data must be symmetrical (e.g., annual x annual) and no data cells can be missing. Finally, you must not change any of the range names stored in the files as this may create problems with the routines included with the files.

Hayne MLE Models:

The **Hayne MLE Models** file is the first file you should open. There are ten visible sheets in the file:

- A. *Inputs* – on this sheet you can enter data for a business segment and choose model options.

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- B. *Exposure Factors* – on this sheet you can specify the “shape” of the data in terms of type and length of exposure periods and the development periods. Heteroecthesious shapes can be specified.
- C. *Hayne MLE* – on this sheet you will find the calculations for the paid and incurred Hayne MLE severity models. You can also specify outliers and tail parameters for each model.
- D. *Diagnostics* – on this sheet you will find the diagnostic graphs described in section 5 of the paper for the severity models.
- E. *Calcs* – on this sheet you will find most of the details of the calculations related to the *Hayne MLE* and *Diagnostics* sheets.
- F. *Results* – on this sheet the results of your severity simulations will be stored and summarized.
- G. *Hayne MLE (Cnt)* – on this sheet you will find the calculations for the closed and reported Hayne MLE frequency models. You can also specify outliers and tail parameters for each model.
- H. *Diagnostics (Cnt)* – on this sheet you will find the diagnostic graphs described in section 5 of the paper for the frequency models.
- I. *Calcs (Cnt)* – on this sheet you will find most of the details of the calculations related to the *Hayne MLE (Cnt)* and *Diagnostics (Cnt)* sheets.
- J. *Results (Cnt)* – on this sheet the results of your simulations will be stored and summarized for the frequency models.

There are also two hidden sheets in the file where the random numbers are stored.

Start with the *Inputs* sheet and enter information about your company name and LOB/segment, then enter paid and incurred loss triangles, closed and reported claim count triangles, earned premium, exposures (if available) and the selected ultimate claim counts. **[Note:** If you copy and paste it's recommended that you use paste special, values so that you do not accidentally erase any range names.] The default model options are set up to match the current modeling framework described in the paper, but they can be changed to see how they impact the final results.

On the *Hayne MLE* {or *Hayne MLE (Cnt)*} sheet, you should set all triangle outliers to zero (Step 9) and make sure all of the cells in the outliers for tail extrapolation are set to zero (Step

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10) – for both the Paid and Incurred {or Closed and Reported} models. [**Note:** Clicking on the Reset Outliers button will do this for you.] You can also reset all of the User Selected parameters to the modeled parameters for all models for both Paid and Incurred {or Closed and Reported} data. [**Note:** Clicking on the Reset Parameters button will do this for you.]

For each model (as selected in the *Inputs* sheet), the parameters for the Hayne MLE model will need to be estimated using a Solver algorithm to minimize the sum of the negative log likelihood. The Solver algorithm is set up for you by using the Find Parameters button for each model and data type. [**Note:** If the fitted parameters are not reasonable, you can manually copy and paste special | values from the initial parameters row into the Calc parameters row and then use the Excel Solver after adding any constraints you think are appropriate – e.g., preventing a parameter from being below a specific value.]

Once the data has been entered and modeled parameters are found, hitting F9 (recalculation) will set up the graphs on the *Diagnostics* {or *Diagnostics (Cnt)*} sheet so that you can assess the assumptions of the model. Clicking on the buttons on this sheet will adjust the scales on the graphs to make them easier to read. You can also change the column used in the graphs at the bottom of the sheet, but you will need to hit F9 to update the graphs.

Using the graphs on the *Diagnostics* {or *Diagnostics (Cnt)*} sheet, you can manually select parameters and remove outliers (in the *Hayne MLE* {or *Hayne MLE (Cnt)*} sheet) to adjust the model fit to the underlying assumptions (See section 5 of the paper for more guidance). For new parameters, you can type in values or formulas as the existing formulas will be reset using the button noted above. For the outlier triangle, a one is used to indicate a cell that will be removed from the calculations (i.e., given zero weight), otherwise use a zero.

After you are satisfied with the model assumptions, you can run simulations for each data type (e.g., Paid or Incurred {or Closed and Reported}) and model type (e.g., Berquist-Sherman, Cape Cod, etc.) combination on the *Inputs* sheet. These ten different combinations give you ten different Hayne MLE models you can run for each LOB/segment by data type.¹ For each data type and model type you will need to find the model parameters and review diagnostics before running simulations.

Set the number of iterations you want to use in the simulation process (from 10 to 10,000) and use the same number of iterations for every model you run for each LOB/segment. [**Note:** While the model will accommodate up to 10,000 iterations it is not designed for speed

¹ The total number of models that can be combined is ten per data type (i.e., severity or frequency). You can also run the combined frequency-severity models for each model and data type. The file is only set up to allow one selected model type for both the severity and frequency models, but there is no technological reason why different severity and frequency models could not be combined, it is simply a matter of simplicity.

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so you should consider limiting the number to say 100 or less if you are only interested in following the calculations.] You can also input the four percentiles you wish to see in the results summaries (the percentiles can be changed at any time).

To run each model, use the following steps:

1. Click on the Generate Random Values button to generate all the random numbers for the model. You should generate new random numbers for each model to avoid creating correlation between the models.
2. Click on the Run Simulations button to run all of the simulations and save the results to the *Results* {or *Results (Cnt)*} sheet.
3. Review the summaries on the *Results* {or *Results (Cnt)*} sheet to make sure you don't need to adjust the model assumptions. [**Note:** You can drill down to any individual iteration in the model by entering the iteration number on the *Inputs* sheet (in the cell two to the right of the Iterations cell), hitting F9 and then reviewing the calculations on the *Hayne MLE* {or *Hayne MLE (Cnt)*} sheet.]
4. Save the **Hayne MLE Models** file in a common data directory using a different file name for each model and LOB/segment. [**Note:** To save file size you can click on the Clear Random Values button, which will remove the data generated in Step 1. Similarly, clicking on the Clear Results button will delete the simulation output on the *Results* {or *Results (Cnt)*} sheet, but you should not do this for any file you want to combine for the next model.]

Repeat these steps for each model and LOB/segment (separately for severity and frequency models). Buttons are also include to run a joint frequency-severity model, but the key result for these models is still the unpaid claim estimates.

Best Estimate:

After each model has been run and saved for a LOB/Segment, you can open the **Best Estimate** file and combine the results. There are two visible sheets in the file:

- A. *Inputs* – on this sheet you can import or enter data for a LOB/Segment and select model weights.
- B. *Results* – on this sheet the results of your simulations will be stored and summarized.

There is also one hidden sheet in the file where the random numbers are stored.

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Start with the *Inputs* sheet and enter the directory path where you saved the **Hayne MLE Models** files for the LOB/Segment. [**Note:** All files for a LOB/Segment must be in the same directory and the path should end with a backslash.] Next, select the data type you are weighting (i.e., frequency or severity) so that the routines will import and combined the desired data type. Next, select the number of files you want to combine, enter the file name for each of the **Hayne MLE Models** files next to the Model File labels and select the Model Type for each model. [**Note:** the default model types are the ten Hayne MLE variations, but you can use a model type more than once.] After this information has been entered, you can click on the Import Raw Data from Model File 1 button which will import all of the rest of the data on the *Inputs* sheet, except the model weights.

Once the raw data has been imported, you must enter weights in the Model Weights by Accident Year table. Ideally, you should select the weights such that for each year the total of the weights by model sum to 100%, but if the weights do not sum to 100% each model will be selected in proportion to the sum. You can also input the four percentiles you wish to see in the results summaries (the percentiles can be changed at any time).

To combine the model results into your best estimate, use the following steps:

1. Click on the Generate Random Values button to generate all the random numbers for the combination process.
2. Clicking on the Combine Results button will open each model sequentially; combine the results based on the weights you specified by year and save the combined results to the *Results* sheet.
3. Review the summaries on the *Results* sheet to make sure you don't need to adjust the model weights.
4. Save the **Best Estimate** file in a common data directory using a different file name for each LOB/segment. [**Note:** To save file size you can click on the Clear Random Values button, which will remove the data generated in Step 1. Similarly, clicking on the Clear Raw Data and/or Clear Results buttons will delete the raw data on the *Inputs* sheet and simulation output on the *Results* sheet, respectively, but you should not do this for any file you want to combine with a **Best Estimate** file for another LOB/Segment.]

Repeat these steps for each LOB/segment.

Aggregate Estimate:

After each LOB/Segment has been combined and saved, you can open the **Aggregate Estimate** file and aggregate the results. There are two visible sheets in the file:

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A. *Inputs* – on this sheet you can import or enter data for three LOB/Segments and select the correlation assumptions.

B. *Results* – on this sheet the results of your simulations will be stored and summarized.

There are also four hidden sheets in the file where the correlation ranks are stored and results for three different LOB/Segments can be found.

Start with the *Inputs* sheet and enter the directory path where you saved the **Best Estimate** files for each of the three LOB/Segments. [**Note:** All LOB/Segment files must be in the same directory and the path should end with a backslash.] Next, select the data type you are weighting (i.e., frequency or severity) so that the routines will import and combined the desired data type. Next, enter the file name for each of the **Best Estimate** files next to the appropriate LOB file number. After this information has been entered, you can click on the Import Raw Data from LOB Files button which will import all of the rest of the data on the *Inputs* sheet and calculate the correlations between the residuals in the LOBs.

Once the raw data has been imported, you must select a correlation matrix assumption. You can use the Select Correlation button to select one of the calculated correlation matrices or to enter a constant value, or you can enter a unique value for each LOB pair. You can also input the four percentiles you wish to see in the results summaries (the percentiles can be changed at any time).

Calculating the correlation ranks to match the selected correlation assumption using the Iman-Conover method can be done by clicking on the Generate Rank Values button. If you would like to use a different method, you can generate the ranks (based on your correlation assumption and number of iterations) using a separate process (e.g., using a Copulas), paste them in the “Correlation Ranks.xls” file and then save the file using another name. [**Note:** The **Correlation Ranks** file has some ranks generated based on different correlation assumptions but these should be deleted and replaced.]

To combine the best estimate results into your aggregate estimate, use the following steps:

1. Click on the Import Results Data from LOB Files button to import the results from each of the best estimate files into their respective hidden LOB sheet.
2. Click on the Generate Rank Values button to create rank values or the Import Rank Values button to import the rank values you created outside of this file for the aggregation process.
3. Click on the Aggregate Results button to combine the results from each of the LOB files using the correlation ranks and save them to the *Results* sheet.

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4. Review the summaries on the *Results* sheet to make sure you don't need to adjust the correlation assumption.

Save the **Aggregate Estimate** file using a different file name. [**Note:** To save file size you can click on the Minimize Result Data and Clear Rank Values buttons, which will remove the all data from Step 1 not used in the Results sheet and the rank values from Step 2, respectively. Similarly, clicking on the Clear Raw Data, Clear Result Data and/or Clear Results buttons will delete the raw data on the *Inputs* sheet, all data in the hidden LOB sheets and simulation output on the *Results* sheet, respectively, but you should not do this if you want so save everything on the *Results* sheet.]

Hayne MLE Model Options:

In the **Hayne MLE Models** file, the Model Options in the *Inputs* and *Hayne MLE* {or *Hayne MLE (Cnt)*} sheets can be changed to test out different variations on the Hayne MLE algorithm. Below is a brief description of each option.

Inputs Sheet Options:

- 1) *Selected Claim Adjustment* – This option allows the value triangles to be divided by either the *Ultimate Claim Count* (Average Severity), *Exposures* (Pure Premiums), or *Earned Premiums* (Loss Ratios) for use in parameterizing a model. *None* is also an option, in which case no adjustment to the data is made.
- 2) *Include Parameter Uncertainty* – This option is used to determine whether the model parameters will be sampled during the simulation process or not. [Default: Yes]
- 3) *Include Process Variance* – This option is used to either include or exclude process variance for the sample future incremental values during the simulation process. [Default: Yes]
- 4) *Include Residual Adjustment* – This option is used to either “shift” mean and standard deviation from the sampled parameters in order to effectively adjust the standardized residuals to $N(0, 1)$. [Default: Yes]
- 5) *Correlate Paid/Inc {or Clsd/Rptd} Process Variance* – This option is used to include or exclude correlation of the random numbers used for the process variance for both paid and incurred {or closed and reported} data. [Default: No]
- 6) *Correlate Paid/ Closed Process Variance* – This option is used to include or exclude correlation of the random numbers used for the process variance within the joint frequency-severity model for both paid and closed data. [Default: No]

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- 7) *Paid/Incurred Correlation* – This option is used to select the correlation coefficient between the paid and incurred process variance (i.e., $-1 \leq PV \leq 1$). [Default: 0]
- 8) *Triangle Size* – This value is used to set up the triangle size. It can be any value from 5 (5 x 5 triangle) to 10 (10 x 10 triangle). [Default: 10]

Hayne MLE Sheet Options (separate for Paid and Incurred {or Closed and Reported} Data):

- 9) *Outliers* – In Step 4, any individual incremental cell can be excluded from the model parameterization (i.e., given zero weight) by changing the outlier triangle cell to one. [Default: 0]