AKUR8
RESERVING

Arius

Stochastic Compilation Module

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1. Stochastic Compilations

The Arius compilation module allows you to combine stochastic models across multiple projects, segments, and model types. It significantly expands the combination capabilities found within the Overdispersed Poisson (ODP) model. For example, while the ODP Summary collections allow you to combine various ODP Bootstrap models by assigning a weight to the results of each model (within a segment), the compilation module allows you to combine results across any combination of models (including Mack and Hayne) across multiple segments and projects. Likewise, where the ODP Bootstrap Aggregation node allows for the aggregation of segments within an Arius project, the new compilation module allows for the aggregation of results across segments from multiple projects.

COMPILATION TYPES

The compilation module provides two different types of compilations,

- Weighted models, which allow you to blend multiple sets of outputs into a single view using a weighted average approach; and
- Aggregate (or Add) models, which allow you to add multiple sets of outputs into a single view, accounting for correlation between them.

Both approaches start with the incremental output that results from running the various individual models. The two approaches differ in terms of additional input requirements as well as methodology.

Weighted models are analogous to the weighting found in the ODP model. Once you have reviewed and finalized the results for each input model in the iterative process described in the *Arius Stochastic User Guide*, you can blend them by assigning a weight to the results of each model. Similar to the process of weighting the results of different deterministic methods to arrive at an actuarial "best estimate", the process of weighting the results of different stochastic models will result in an actuarial "best estimate of the distribution".

Similar to the ODP model weighting, you will select weights for each model and exposure period.

The **Add models** compilations are analogous to the ODP Bootstrap Aggregation found within the Arius Stochastic module, and aggregates the results of multiple sources, taking into account the estimated correlation among them. While the weighted models (above) require an input vector of weights for each model, the Add models require you to provide a correlation matrix and the degrees of freedom. Correlating models together is discussed in detail in Appendix C of the *Arius Stochastic User Guide*.

Any given project can have a number of both types of compilations saved within them, limited (practically) by the amount of memory Arius is allowed to utilize.

2. Building Compilations – Step By Step Guide

Arius provides a straightforward process for compiling a number of stochastic models into a single summary results set.

- You must first run the individual models that you want to combine, saving their incremental iterations in CSV output files.
- You can then create a new compilation, giving it a name and description, and identifying other related details such as what type of approach to use (Weighted or Add) and how many iterations to run.
- Once the basic compilation is defined, you will identify the CSV files containing incremental iterations to provide the input for the models that you want to combine.
- With all the input models identified, you can then specify either
  - the relative weighting for each input model for Weighted models, or
  - the correlation matrix and the degrees of freedom for Add models.
- Finally, you will select **Run Compilation** and Arius will develop the summary reports similar to those that are available for individual stochastic models.

STEP 0: SET UP EXTRAPOLATED PERIODS

The compilation module, by default, will use the number of exposure periods and development periods found in the project settings of the APJ file in which it is saved. However, there are many times when development beyond the triangle is expected, and included in the stochastic output. To extend the number of periods for which the stochastic module will generate results, the **Options** button on the compilation module window allows you to enter a number for the periods of extrapolation.

For example, if you're working in a 10x40 APJ file, and have model output extrapolated 20 additional periods, to accurately incorporate these results in the compilation module, the **Number of Periods in Extrapolation** option must be set to 20. This is a global option and it applies to all compilations within the APJ file. Any compilations or sources that do not extend to the end of the extrapolated periods count will have results for those calendar periods equal to zero (as expected).

STEP 1: PREPARING CSV (OR ALTERNATIVE) SOURCES

The compilation module uses files of individual incremental iterations to generate a compilation.

This module has the following requirements for the incremental iterations:[1]

- Iterations must be stored in a CSV file, with the first column containing the iteration number, the second containing an exposure period identifier, and the subsequent columns representing periods of development (or extrapolation).
- The input source CSV files must have identical data structures, and must be of an identical date structure to the APJ project in which the compilation is being generated (excluding extrapolated periods). For example, you will generate compiled results from CSV files with 10 exposure periods and 40 development periods in an APJ file that has the same 10x40 structure.


Note

Compilation results will rely on the date structure of the APJ file in which the compilation is created (for labeling purposes).

[1] These are the requirements as of Arius version 2019a.

While the compilation module can use properly formatted output from any source, Arius will generate these source CSV files when you select **All Incrementals, by Iteration** under MODEL OPTIONS | OPTIONS **Save Results to File?**. This will generate CSV output files for all selected stochastic models when you run simulations of the individual models. The CSV output files will initially be saved in *C:\Users\username\Documents\Milliman\Arius\Sim_Results*, although you do not have to keep them in this location to use them with the compilation module. As noted below, the compilation module can also use previously created compilations as a source within the same APJ file.

STEP 2: IDENTIFYING ADDITIONAL ASSUMPTIONS

The compilation module will generate loss ratio exhibits if you provide premium information. As premium information is not currently captured in the Arius incremental iteration output, you must compute this outside of Arius and copy it into the compilation module for the corresponding compilations.

Finally, the compilation module relies on several inputs from the Arius Stochastic **Model Options** dialog. These include the **Seed Value**, the **Save Results to File?** option, and the **Result Percentiles**.

Note that the compilation module will work with Time Horizon output, and will also work with discounted and undiscounted data. However, Arius does not validate that these inputs are congruent, so you must ensure your selected source files are appropriate (i.e., the compilation module will not prevent you from combining time horizon and ultimate output, or discounted and undiscounted output).

STEP 3: SETTING UP THE BASIC COMPILATION STRUCTURE

To generate compilations, navigate to HOME | COMPILATION. This will open the Compilation Library window. Within this library, there are a number of ribbon options:

- **New** will create a compilation. As compilations are created, they will be saved in the left pane under **Aggregation Results**, with a folder icon representing each compilation.
- Existing compilations can be modified using the **Edit** button, then selecting the compilation that you wish to edit from the drop-down box. Similarly, compilations can be removed with the **Delete** button.
- In the event that you wish to reorder the compilations within the file, the **Reorder** button will open a dialog box that allows for this.
- **Run** and **Run All** buttons allow you to run either a specific compilation or all defined compilations.


Note

Compilations will be performed in the order they are listed on the Aggregation Results pane, so compilations which serve as sources for subsequent compilations must appear first.

Clicking **New** will open a window labeled **Create or Edit Compilation**. You will define all assumptions specific to a given compilation in this window. The top input box (Name) will specify the label that will appear in the **Aggregation Results** pane. The second input box (**Description**) is currently unused elsewhere in Arius, and provides the opportunity to note assumptions or comments regarding the compilation.

You can define the number of output iterations for the given compilation, up to a maximum of 50,000. Note that the Weighted models are restricted by the number of iterations in the source files (See the *Iteration Counts* section below).

The fourth row requires you to specify the type of compilation, either **Weight** or **Add**, as described in Section 1. Once you complete Step 4 below, this choice of compilation type will determine what additional data fields open up the lower section of the window, either columns for weights or a matrix

for correlation factors. Note that you can switch between approaches even after you have added the sources (step 4).

STEP 4: ADDING SOURCES TO A COMPILATION

Once the basics of your compilation have been entered, you are ready to define the sources of data you want to combine. You can compile between 1 and 20 unique sources.

Performing any sort of compilation on a single source will result in the reporting tables being populated from that single source, without any additional weighting or aggregation with other files. For example, you might do this to use Arius' reporting capabilities with stochastic model results that were developed outside of Arius (recall from above that the compilation module will work with any properly formatted CSV file, and inputs are not restricted to those from other Arius Stochastic models).

The **Add CSV Files** button allows you to select one or multiple CSV files as inputs into the compilation process. Select a number of files and click **Open** and you will return to the **Create or Edit Compilation** window, updated with your selected input files.

For Weighted models, you will see a column of weights for each CSV file. By default, weights for each exposure period for each input file will be 1.0. For Add models, you will see a row and a column of a correlation matrix for each selected CSV input file. By default, there will be no assigned correlation between sources.

In subsequent compilations, you can use the **Add Compilation** dropdown box to use a previously parameterized compilation as a source. CSVs and compilations can be used as inputs within the same compilations.

To remove a source (either a compilation or a CSV file) from the current compilation, click the column header associated with that source, and click the **Remove** button.

As the filenames associated with the CSV files can be long and become unreadable when initially added to a compilation, the **Edit CSV File** dialog allows you to customize the **Abbreviated Name** for each CSV source file. This function can be accessed by clicking the column header associated with a source and clicking the **Edit CSV File** button. You can also use this Edit CSV File dialog to change the CSV file to which a column is referring. When changing the CSV, any assigned weights or correlation coefficients will remain populated as before. This may be useful when updating existing compilations for additional exposure periods or alternative stochastic scenarios, allowing you to avoid reparametrizing each compilation.

STEP 5: POPULATING WEIGHTS, CORRELATION COEFFICIENTS AND PREMIUMS

When you have identified all input sources, you must enter a vector of weights for Weighted models or correlation coefficients for Add models for each source within the compilation.

For Weighted models, weights must be non-negative, but are not required to sum to 1. When running the compilations, they will be normalized to equal 1 for each exposure period.

For Add models, the correlation coefficients must be between -1 and 1 (inclusive), and the correlation matrix must be positive definite. Also shown at the bottom of this table are the degrees of freedom for the T-distribution used in the correlation, which affects the strength of the correlation in the tail of the distributions. The degrees of freedom range between 1 and 99. Ninety-nine will provide a correlation based on a normal distribution. As the degrees of freedom move closer to 1, the model will give a correlation based on a fatter-tailed T-distribution. Having a fatter tail implies an expectation of stronger correlations in the extreme outcomes (for a given level of correlation).

If you have premium information you wish to use to calculate the Loss Ratios object, there is an input vector that allows for manual population of the premium applicable to a given compilation by exposure period.

STEP 6: RUNNING COMPILATIONS

After you have defined your compilations, you have two options for running them. The **Run** button will run a single compilation. The **Run All** button will run all defined compilations within the file (all compilations listed under **Aggregation Results**). As a note, when your file contains a compilation that relies on other compilations as a source, running a single compilation is not an option—you must use **Run All**.

Further, if there are dependencies among the compilations, the compilations on which subsequent compilations rely must be listed prior to the dependent compilation or you will receive an error message informing you to review dependencies. The **Reorder** button allows you to ensure that your compilations are defined in the proper order.

STEP 7: REVIEWING RESULTS

The stochastic compilation module will provide, for each compilation, all of the same tables and graphs of results as the individual model collections within Arius Stochastic (with the exception of the CDR table for Time Horizon models). Please refer to the *Arius Stochastic User Guide* for detailed descriptions of the results tables. Note that if you do not provide premium information, the Loss Ratios object will be populated with zeros.

3. Iteration Counts

WEIGHTED MODELS

Weighted models are dependent on the input files to determine the number of maximum iterations. Arius will create the number of iterations you specified or the maximum number determinable by the provided source files, whichever is smaller. In the event that you request more iterations than are necessary based on the input files, Arius will inform you as to the actual number of iterations generated.

AGGREGATE MODELS

Unlike the Weighted models, the Add models are not restricted to a specified number of iterations. Rather, source iterations will be drawn multiple times as needed for the purposes of compilation. Replication is performed in a manner so as not to distort the underlying results.

4. Known Issues

CASH FLOW & RUNOFF TABLES – ASYMMETRIC TRIANGLES (ARIUS 3.2.1 ONLY)

Currently, the cash flow and runoff tables do not return correct values for asymmetric triangles (i.e., triangles in which the length of the development period is less than that of the exposure periods—for example, annual X quarterly). All remaining compilation results tables are populated correctly. To generate the appropriate cash flow and runoff tables, it is recommended that you export compilation incrementals and perform the necessary calculations in Excel.

This issue has been corrected in the subsequent Arius release, version 2019a.

HAYNE MLE MODEL OUTPUT INCREMENTALS

While not directly an issue with the compilation module itself, there is a known issue with Arius Stochastic incremental output for the eight Hayne MLE models. Within the CSV output files, the Iteration column is incorrectly populated, and you cannot use it within the compilation module without a quick modification. In Microsoft Excel, this can be done by placing the following formula in Cell A2, and filling the entire column: =countifs(B2:B2,B2).

MACK MODEL OUTPUT INCREMENTALS (WITH ALL PRIOR ROW ENABLED)

For Arius data structures with an All Prior row enabled, the incremental iteration output CSVs for the Mack models will generate a row of NaN values for the first exposure period (the Prior row). The compilation module will not recognize these values, and will generate an error message. To use this output, replace the NaNs in the Prior row with any numeric value.

If utilizing the All Prior row, it is not recommended to apply any weights (in a weighted model) to the first exposure period of any Mack method, as these will (likely) be manual corrections. In addition, it is not recommended to utilize the Mack method in Aggregate models for structures with an All Prior row.

TIME HORIZON MODELING

While the compilation module will run on incremental output generated using Arius' time horizon model, it does not currently return the Claim Development Result (CDR) model object.