AKUR8
RESERVING

Arius

Drivers of Change analysis

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1. Overview

One of the important skills of a reserving analyst is to know how to best respond to observed changes in data. When claims costs come in higher than expected, a logical response is often to increase ultimate losses. However, the adverse development could be due to a speed-up of payments or a change in the mix of business. If the message changes from one quarter to another, from saying that business is worsening and reserves need to increase to saying the opposite, your credibility as an analyst may suffer. With more companies using an actuary-in-the-box approach that automatically updates projected ultimate losses each quarter, it's crucial to understand the reasons for the changes in your ultimate losses.

DRIVERS OF CHANGE REPORT

A helpful way to understand this is to use a **Drivers of Change** report. This report splits the change in ultimates into the change in data and the change in assumptions to help you more effectively evaluate what is causing the change in reprojected ultimates. This provides valuable information to the management team that books reserves. It also helps monitor your reaction to changes in the data and helps you more carefully examine of the reliability of your method assumptions.

The sample Arius file provides a *Drivers of Change in Ultimate Loss* collection under the Deterministic node. These examples provide insight into what is causing the change in ultimate loss compared to the last valuation date. (See the Arius_Sample.apj found in …\Documents\Milliman\Arius\DemoFiles.)

This collection includes the REPORTS | USER DEFINED | **#602 Drivers of Change in Ultimate Loss** table as well as a graph that shows columns (6)-(9) as a stacked bar and column (10) as a line. It is also common to depict these changes as a waterfall graph, which you can create by exporting this report to a third-party visualization tool.

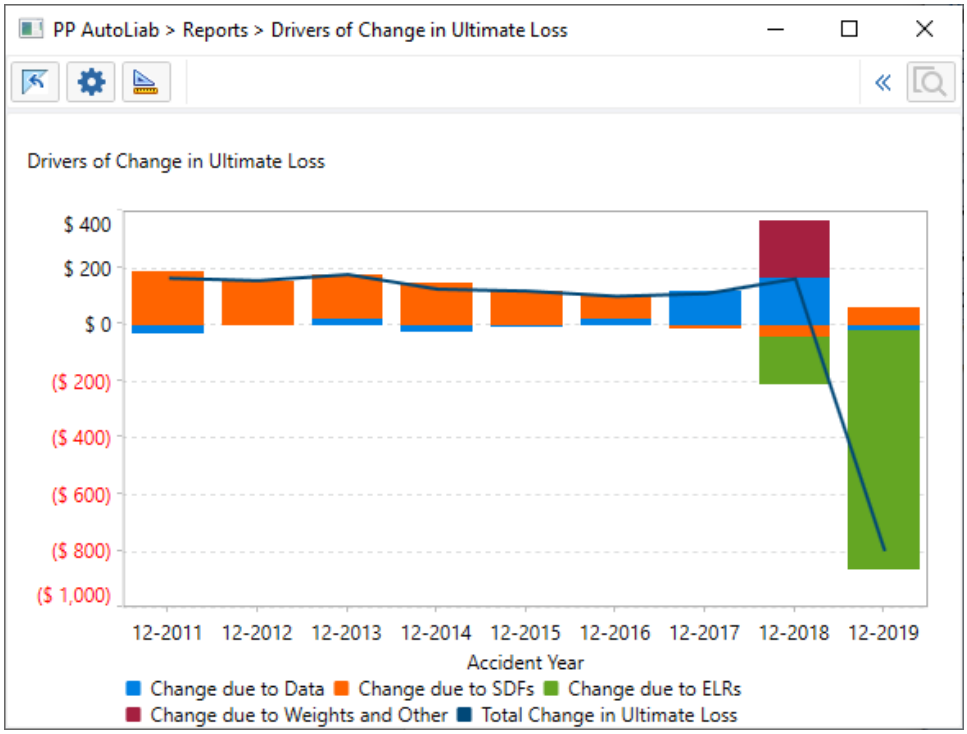
Sample report and graph

PP AutoLiab > Reports > 602 - Drivers of Change in Ultimate Loss

602 - Drivers of Change in Ultimate Loss

Accident Year	Prior Ultimate Loss	Ultimate Loss Based on Prior SDFs, ELRs and Weights	Ultimate Loss Based on Prior ELRs and Weights	Ultimate Loss Based on Prior Weights	Selected Ultimate Loss	Change due to Data (2) - (1)	Change due to SDFs (3) - (2)	Change due to ELRs (4) - (3)	Change due to Weights and Other (5) - (4)	Total Change in Ultimate Loss (5) - (1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
12-2011	$ 21,326	$ 21,299	$ 21,492	$ 21,492	$ 21,492	($ 27)	$ 194	$ 0	$ 0	$ 167
12-2012	14,383	14,385	14,541	14,541	14,541	2	156	0	0	158
12-2013	13,250	13,272	13,430	13,430	13,430	22	157	0	0	180
12-2014	8,775	8,752	8,902	8,902	8,902	(22)	150	0	0	128
12-2015	8,297	8,295	8,418	8,418	8,418	(2)	123	0	0	121
12-2016	7,054	7,076	7,157	7,157	7,157	21	82	0	0	103
12-2017	7,730	7,851	7,842	7,842	7,842	121	(8)	0	0	112
12-2018	11,221	11,387	11,348	11,182	11,386	166	(39)	(166)	204	165
12-2019	15,951	15,934	16,001	15,155	15,155	(17)	67	(845)	0	(796)
12-2020										
Total	$ 107,986	$ 108,250	$ 109,132	$ 108,121	$ 108,324	$ 264	$ 882	($ 1,012)	$ 204	$ 338

100%



This example shows that the ultimate loss improved in the earlier years mainly because of a change in development patterns, and for the most recent year, the ultimate loss decreased because of a better initial expected loss ratio for the Bornhuetter-Ferguson method.

2. Details behind the sample calculations

The calculations behind a *Drivers of Change* analysis depend on the methods or models you rely on when projecting ultimate losses. In the example we use in this document, ultimate losses are selected based on a weighted average of the following four methods:

- METHODS | LOSS | #1 Paid Loss Development
- METHODS | LOSS | #2 Incurred Loss Development
- METHODS | LOSS | #17 Bornhuetter-Ferguson Using Ultimate Premiums and Paid Loss
- METHODS | LOSS | #18 Bornhuetter-Ferguson Using Ultimate Premiums and Incurred Loss

You can easily expand these examples to account for additional methods, changes in ultimate premium, changes due to exchange rates, or other factors that affect your ultimate loss calculation. You can approach this by starting with the prior ultimate selection and stepping through recalculating the ultimate loss by

1. changing the data,
2. changing the selected development factors,
3. changing the Bornhuetter-Ferguson initial expected loss ratios, and
4. continuing in this fashion across any other method assumptions.

The table below helps to depict these steps and makes up the basis for columns (1) through (5) in REPORTS | USER DEFINED | **#602 Drivers of Change in Ultimate Loss**.

	START	STEP 1	STEP 2	STEP 3	END
METHOD INPUT	**PRIOR ULTIMATE LOSS**	**ULTIMATE LOSS BASED ON PRIOR SDFS ELRS AND WEIGHTS**	**ULTIMATE LOSS BASED ON PRIOR ELRS AND WEIGHTS**	**ULTIMATE LOSS BASED ON PRIOR WEIGHTS**	**SELECTED ULTIMATE LOSS**
Paid Loss	Prior	Current	Current	Current	Current
Incurred Loss	Prior	Current	Current	Current	Current
Ultimate Premium	Prior	Current	Current	Current	Current
Paid SDFs	Prior	Prior	Current	Current	Current
Incurred SDFs	Prior	Prior	Current	Current	Current
ELRs	Prior	Prior	Prior	Current	Current
Method Weights	Prior	Prior	Prior	Prior	Current

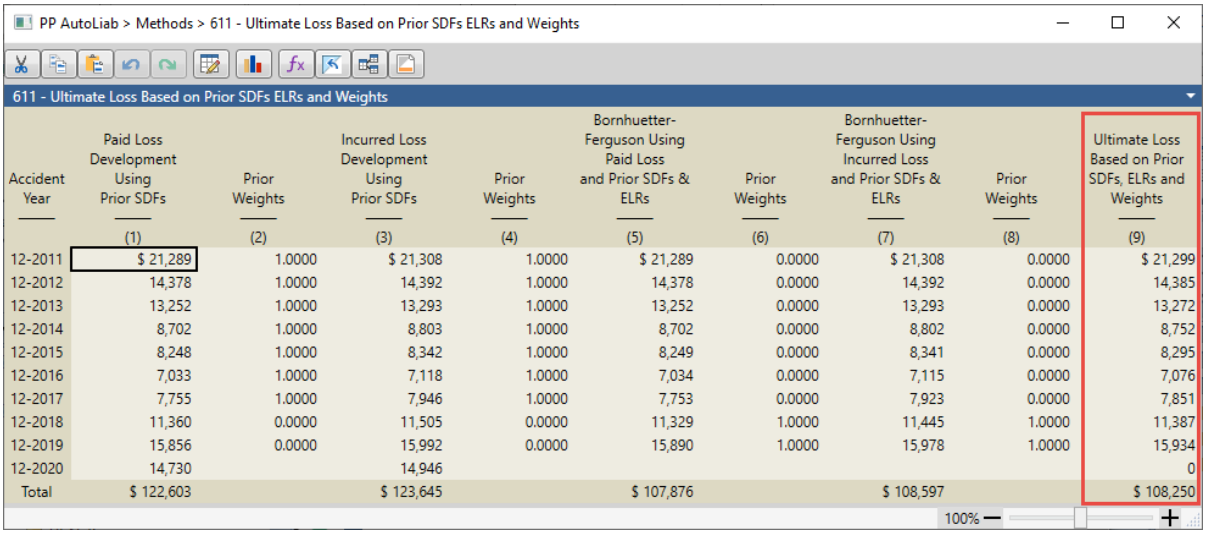
REQUIRED USER DEFINED TABLES

You will use several user defined tables to support the calculations behind a **Drivers of Change** report, and examples of these are included in the file Arius_Sample.apj.

To calculate columns (2) through (4) in REPORTS | USER DEFINED | **#602 Drivers of Change in Ultimate Loss**, the report calculates ultimate losses for each of the four methods using the mix of current and prior data as prescribed above, and weights them together using the prior method weights.

Column (2) in the report references METHODS| USER DEFINED | **#611 Ultimate Loss Based on Prior SDFs ELRs and Weights** which weights together the following underlying methods.

- METHODS | USER DEFINED | #605 Paid Loss Development Using Prior SDFs
- METHODS | USER DEFINED | #606 Incurred Loss Development Using Prior SDFs
- METHODS | USER DEFINED | #607 BF Using Paid Loss and Ultimate Premiums and Prior SDFs and ELRs
- METHODS | USER DEFINED | #608 BF Using Incurred Loss and Ultimate Premium and Prior SDFs and ELRs


PP AutoLiab > Methods > 611 - Ultimate Loss Based on Prior SDFs ELRs and Weights

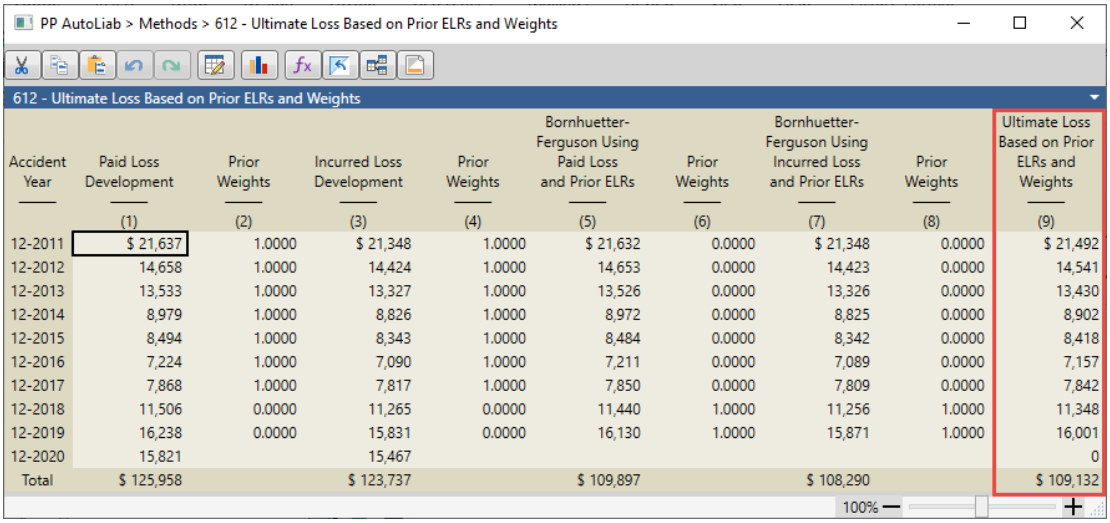
611 - Ultimate Loss Based on Prior SDFs ELRs and Weights

Accident Year	Paid Loss Development Using Prior SDFs	Prior Weights	Incurred Loss Development Using Prior SDFs	Prior Weights	Bornhuetter-Ferguson Using Paid Loss and Prior SDFs & ELRs	Prior Weights	Bornhuetter-Ferguson Using Incurred Loss and Prior SDFs & ELRs	Prior Weights	Ultimate Loss Based on Prior SDFs, ELRs and Weights
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
12-2011	$ 21,289	1.0000	$ 21,308	1.0000	$ 21,289	0.0000	$ 21,308	0.0000	$ 21,299
12-2012	14,378	1.0000	14,392	1.0000	14,378	0.0000	14,392	0.0000	14,385
12-2013	13,252	1.0000	13,293	1.0000	13,252	0.0000	13,293	0.0000	13,272
12-2014	8,702	1.0000	8,803	1.0000	8,702	0.0000	8,802	0.0000	8,752
12-2015	8,248	1.0000	8,342	1.0000	8,249	0.0000	8,341	0.0000	8,295
12-2016	7,033	1.0000	7,118	1.0000	7,034	0.0000	7,115	0.0000	7,076
12-2017	7,755	1.0000	7,946	1.0000	7,753	0.0000	7,923	0.0000	7,851
12-2018	11,360	0.0000	11,505	0.0000	11,329	1.0000	11,445	1.0000	11,387
12-2019	15,856	0.0000	15,992	0.0000	15,890	1.0000	15,978	1.0000	15,934
12-2020	14,730		14,946						0
Total	$ 122,603		$ 123,645		$ 107,876		$ 108,597		$ 108,250

100%

Column (3) in the report references METHODS | USER DEFINED | **#612 Ultimate Loss Based on Prior ELRs and Weights**, which weights together the following underlying methods:

- METHODS | LOSS | #1 Paid Loss Development
- METHODS | LOSS | #2 Incurred Loss Development
- METHODS | USER DEFINED | #609 BF Using Paid Loss and Ultimate Premiums and Prior ELRs
- METHODS | USER DEFINED | #610 BF Using Incurred Loss and Ultimate Premiums and Prior ELRs



PP AutoLiab > Methods > 612 - Ultimate Loss Based on Prior ELRs and Weights

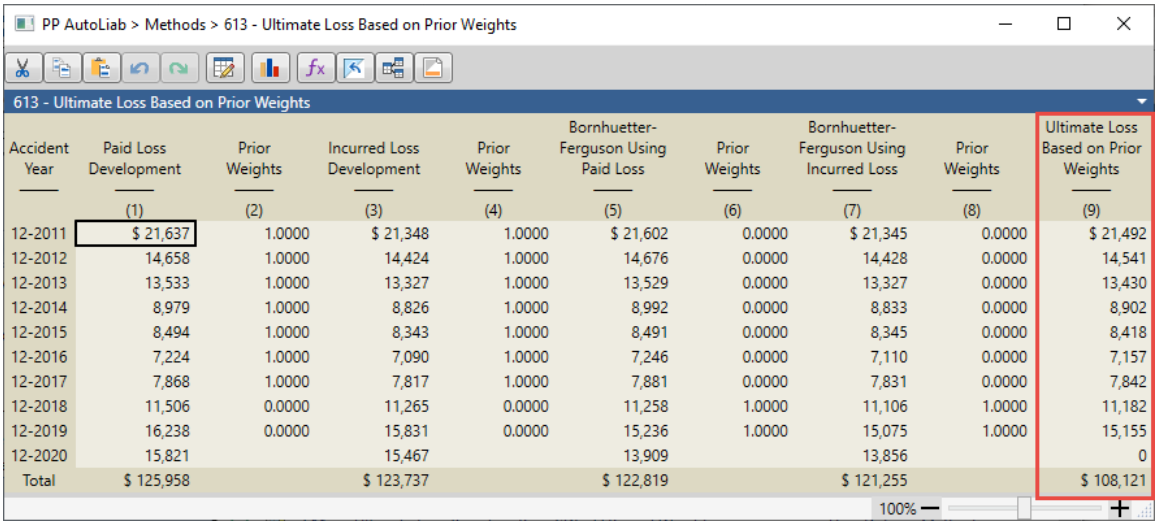
612 - Ultimate Loss Based on Prior ELRs and Weights

Accident Year	Paid Loss Development	Prior Weights	Incurred Loss Development	Prior Weights	Bornhuetter-Ferguson Using Paid Loss and Prior ELRs	Prior Weights	Bornhuetter-Ferguson Using Incurred Loss and Prior ELRs	Prior Weights	Ultimate Loss Based on Prior ELRs and Weights
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
12-2011	$ 21,637	1.0000	$ 21,348	1.0000	$ 21,632	0.0000	$ 21,348	0.0000	$ 21,492
12-2012	14,658	1.0000	14,424	1.0000	14,653	0.0000	14,423	0.0000	14,541
12-2013	13,533	1.0000	13,327	1.0000	13,526	0.0000	13,326	0.0000	13,430
12-2014	8,979	1.0000	8,826	1.0000	8,972	0.0000	8,825	0.0000	8,902
12-2015	8,494	1.0000	8,343	1.0000	8,484	0.0000	8,342	0.0000	8,418
12-2016	7,224	1.0000	7,090	1.0000	7,211	0.0000	7,089	0.0000	7,157
12-2017	7,868	1.0000	7,817	1.0000	7,850	0.0000	7,809	0.0000	7,842
12-2018	11,506	0.0000	11,265	0.0000	11,440	1.0000	11,256	1.0000	11,348
12-2019	16,238	0.0000	15,831	0.0000	16,130	1.0000	15,871	1.0000	16,001
12-2020	15,821		15,467						0
Total	$ 125,958		$ 123,737		$ 109,897		$ 108,290		$ 109,132

100%

Column (4) in the report references METHODS | USER DEFINED | **#613 Ultimate Loss Based on Prior Weights**, which weights together the following underlying methods:

- METHODS | LOSS | #1 Paid Loss Development
- METHODS | LOSS | #2 Incurred Loss Development
- METHODS | LOSS | #17 Bornhuetter-Ferguson Using Ultimate Premiums and Paid Loss
- METHODS | LOSS | #18 Bornhuetter-Ferguson Using Ultimate Premiums and Incurred Loss



PP AutoLiab > Methods > 613 - Ultimate Loss Based on Prior Weights

613 - Ultimate Loss Based on Prior Weights

Accident Year	Paid Loss Development	Prior Weights	Incurred Loss Development	Prior Weights	Bornhuetter-Ferguson Using Paid Loss	Prior Weights	Bornhuetter-Ferguson Using Incurred Loss	Prior Weights	Ultimate Loss Based on Prior Weights
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
12-2011	$ 21,637	1.0000	$ 21,348	1.0000	$ 21,602	0.0000	$ 21,345	0.0000	$ 21,492
12-2012	14,658	1.0000	14,424	1.0000	14,676	0.0000	14,428	0.0000	14,541
12-2013	13,533	1.0000	13,327	1.0000	13,529	0.0000	13,327	0.0000	13,430
12-2014	8,979	1.0000	8,826	1.0000	8,992	0.0000	8,833	0.0000	8,902
12-2015	8,494	1.0000	8,343	1.0000	8,491	0.0000	8,345	0.0000	8,418
12-2016	7,224	1.0000	7,090	1.0000	7,246	0.0000	7,110	0.0000	7,157
12-2017	7,868	1.0000	7,817	1.0000	7,881	0.0000	7,831	0.0000	7,842
12-2018	11,506	0.0000	11,265	0.0000	11,258	1.0000	11,106	1.0000	11,182
12-2019	16,238	0.0000	15,831	0.0000	15,236	1.0000	15,075	1.0000	15,155
12-2020	15,821		15,467		13,909		13,856		0
Total	$ 125,958		$ 123,737		$ 122,819		$ 121,255		$ 108,121

100%

ACCESS TO PRIOR DATA

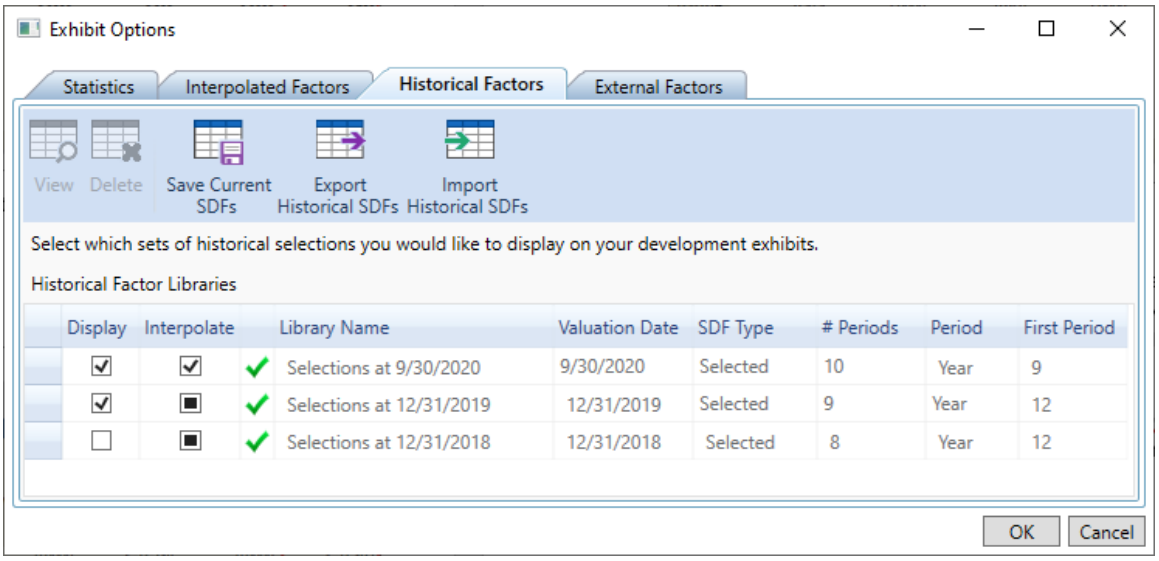
To populate these methods, we need access to the assumptions from the prior analysis. For the four methods in our example, this includes

- selected paid and incurred loss development factors,
- Bornhuetter-Ferguson initial expected loss ratios, and
- method weights.

This data is available either via the Historical Factor Library or Historical Assumption Arrays.

Historical Factor Library

You will find the Historical Factor Library under EXHIBIT OPTIONS | HISTORICAL FACTORS. This library stores all prior selected development factors (SDFs).



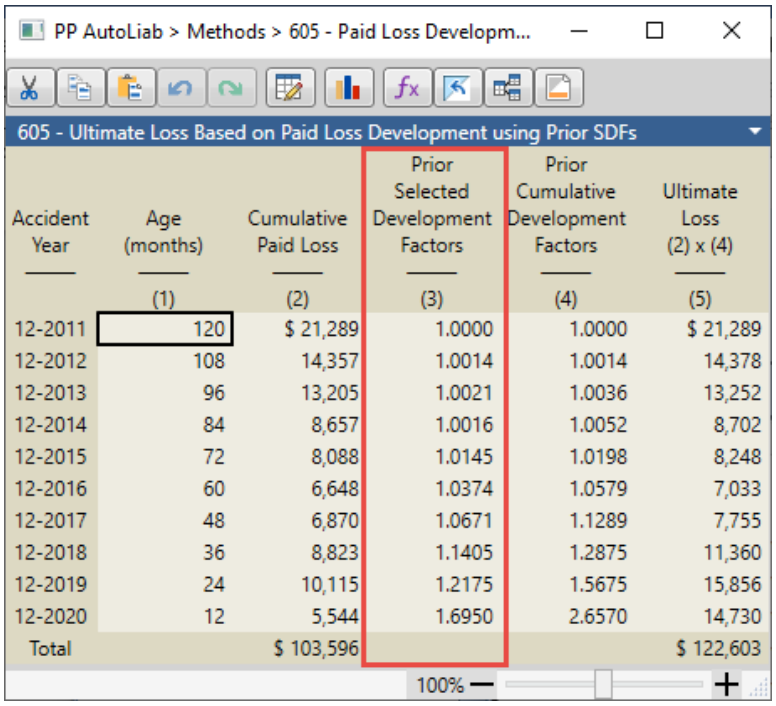
There are three ways to save data into this library:

1. Automatically, when you append a new diagonal via MODIFY STRUCTURE | APPEND NEW EVALUATION PERIOD.
2. Manually, when you click **Save Current SDFs** in this dialog. This step is necessary when you are rolling forward a project to a new evaluation but not appending a new evaluation period (e.g., changing the First Development Age of your Y x Y triangle from 9 months at 9/30 to 12 months at 12/31).
3. Manually, when you use the **Import Historical SDFs** button in this dialog. You can import an Excel or CSV file containing the historical factor sets for the specified segment, exhibit, and valuation date.

You can then access these historical factors in user defined tables with the GetPriorSDF or GetPriorSDFX() functions. For example, in METHODS | USER DEFINED | **#605 Paid Loss Development Using**

Prior SDFs, the GetPriorSDF() function in column (3) returns the factors from the prior Valuation Date using this formula:

ConvertSDFtoCol (SpreadTail (**GetPriorSDF** ("Paid Loss Development"))



Accident Year	Age (months)	Cumulative Paid Loss	Prior Selected Development Factors	Prior Cumulative Development Factors	Ultimate Loss (2) x (4)
	(1)	(2)	(3)	(4)	(5)
12-2011	120	$ 21,289	1.0000	1.0000	$ 21,289
12-2012	108	14,357	1.0014	1.0014	14,378
12-2013	96	13,205	1.0021	1.0036	13,252
12-2014	84	8,657	1.0016	1.0052	8,702
12-2015	72	8,088	1.0145	1.0198	8,248
12-2016	60	6,648	1.0374	1.0579	7,033
12-2017	48	6,870	1.0671	1.1289	7,755
12-2018	36	8,823	1.1405	1.2875	11,360
12-2019	24	10,115	1.2175	1.5675	15,856
12-2020	12	5,544	1.6950	2.6570	14,730
Total		$ 103,596			$ 122,603

Note:
Formulas in Arius require 1) a space before and after parenthesis and 2) quotes around table names.

For further guidance on Historical Factor Libraries within Arius, refer to the document "Historical factor on exhibits" found in Arius under HELP | USER DOCUMENTATION.

For further guidance on the GetPriorSDF() and GetPriorSDFX() functions, refer to the document "Formula functions" found in Arius under HELP | USER DOCUMENTATION.

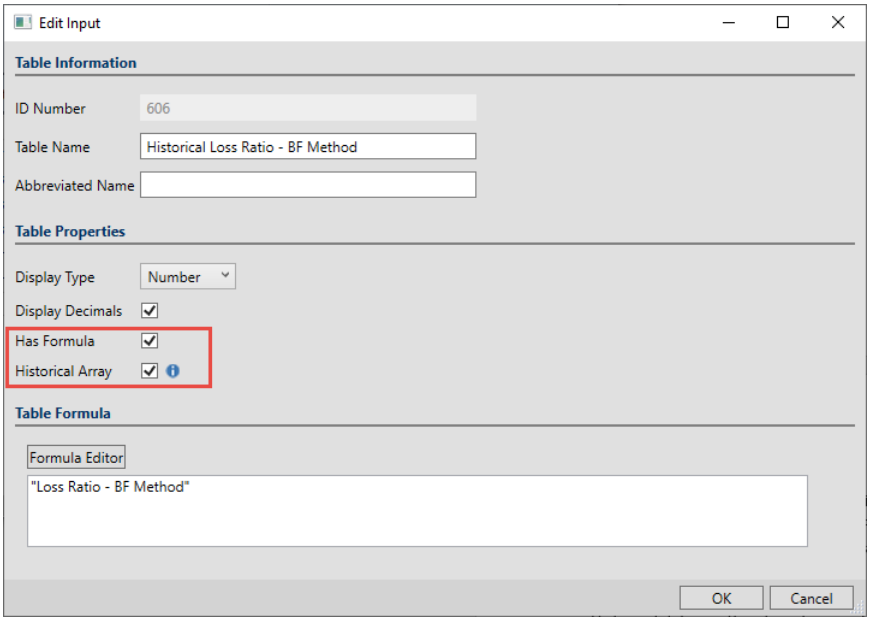
Historical arrays

You can create Historical Arrays as new user defined input triangles. These arrays are special in that the last diagonal links to any column array in Arius (or any formula that results in a column array). Each time you append a new evaluation period, Arius stores the column data into previous diagonals, allowing you to track assumptions over time. For example, see the five system historical arrays in DATA | RESULTS | **#35 HISTORICAL ULTIMATE LOSS**.

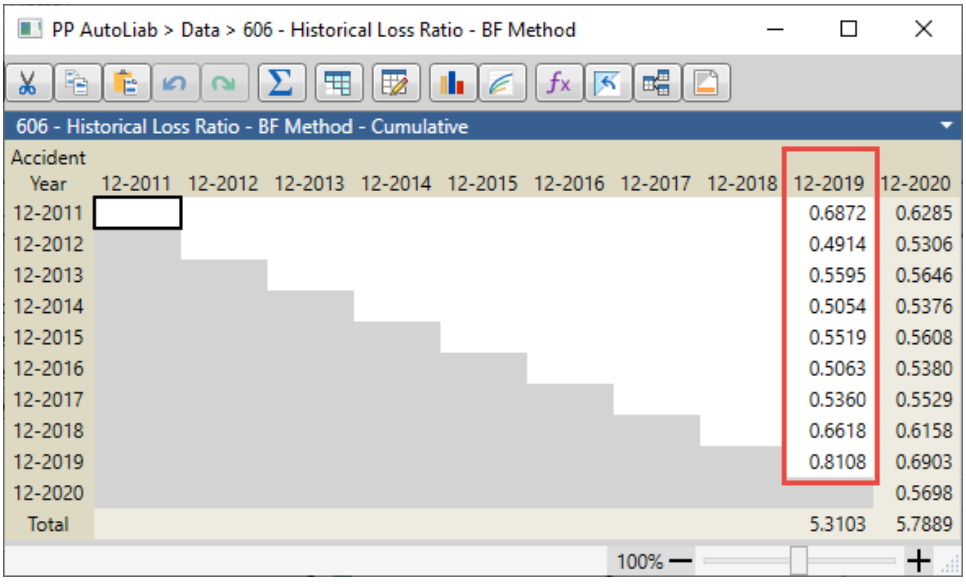
The user-defined methods described above reference the following historical arrays from the OBJECT LIBRARY |DATA | USER-DEFINED folder:

- METHODS | USER DEFINED | #606 Historical Loss Ratio – BF Method
- METHODS | USER DEFINED | #607 Historical Weights – Paid Loss Development
- METHODS | USER DEFINED | #608 Historical Weights – Incurred Loss Development
- METHODS | USER DEFINED | #609 Historical Weights – BF Using Ultimate Premiums and Paid Loss
- METHODS | USER DEFINED | #610 Historical Weights – BF Using Ultimate Premiums and Incurred Loss

To extend this functionality to an existing user defined input triangle, or to create a new user defined input triangle, check the box **Has Formula** and then check the box **Historical Array**. You can then enter any valid function that returns a columnar array, such as **Loss Ratio – BF Method**.



The results are shown in a calendar formatted triangle where the last column is shaded, as it is linked to the columnar array resulting from the formula above. The white interior part of the triangle is populated automatically as you roll the project forward to the next valuation date (you can also manually enter data here).



You can then access this historical data in your user-defined tables via the Diagonal() or DiagonalX() functions. For example, the column highlighted above is referenced in column (3) in METHODS | USER DEFINED | **#609 BF Using Ultimate Premiums and Paid Loss and Prior ELRs**, using this formula:

Diagonal2 (Cumulate ("Historical Loss Ratio - BF Method"))

PP AutoLiab > Methods > 609 - BF Using Ultimate Premiums and Paid Loss and Prior ELRs

609 - Ultimate Loss Based on BF Using Ultimate Premiums and Paid Loss and Prior ELRs

Accident Year	Age (months)	Ultimate Premiums	Prior Selected Loss Ratio	Expected Ultimate Loss (2) x (3)	Cumulative Development Factors	Percentage Undeveloped 1 - 1/(5)	Undeveloped Paid Loss (4) x (6)	Cumulative Paid Loss	Ultimate Loss (7) + (8)	Calculated Loss Ratio (9) / (2)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
12-2011	120	$ 31,033	0.6872	$ 21,326	1.0163	1.61 %	$ 343	$ 21,289	$ 21,632	0.6970
12-2012	108	29,269	0.4914	14,383	1.0210	2.06 %	296	14,357	14,653	0.5006
12-2013	96	23,683	0.5595	13,250	1.0248	2.42 %	321	13,205	13,526	0.5711
12-2014	84	17,360	0.5054	8,775	1.0372	3.58 %	315	8,657	8,972	0.5168
12-2015	72	15,033	0.5519	8,297	1.0502	4.78 %	396	8,088	8,484	0.5644
12-2016	60	13,933	0.5063	7,054	1.0867	7.98 %	563	6,648	7,211	0.5175
12-2017	48	14,423	0.5360	7,730	1.1452	12.68 %	980	6,870	7,850	0.5443
12-2018	36	16,955	0.6618	11,221	1.3041	23.32 %	2,617	8,823	11,440	0.6747
12-2019	24	19,674	0.8108	15,951	1.6054	37.71 %	6,015	10,115	16,130	0.8199
12-2020	12	22,601			2.8537	64.96 %		5,544		
Total		$ 203,963		$ 107,986			$ 11,845	$ 103,596	$ 109,897	

100%

GetWeights function

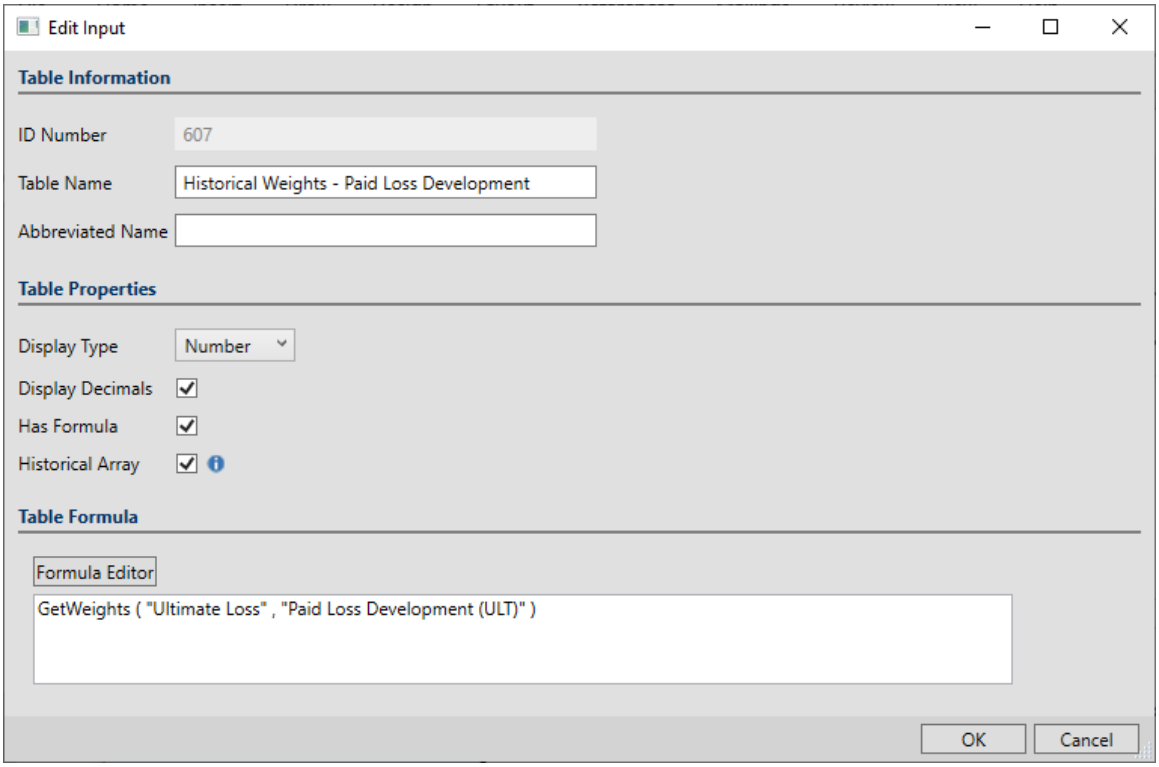
To populate the prior method weights assumptions, we use the historical array feature along with the GetWeights() function. The GetWeights() function returns a column array with the weights corresponding to an input (or method) that is used in either a formula-driven assumption array or a **Comparison of Ultimate** report. In our example, we want the weights associated with the methods from REPORTS | LOSS | **#3 Comparison of Ultimate Loss Estimates** from the prior analysis.

PP AutoLiab > Reports > 3 - Comparison of Ultimate Loss Estimates

3 - Comparison of Ultimate Loss Estimates

Accident Year	Paid Loss Development	Weights- Paid Loss Development	Incurred Loss Development	Weights- Incurred Loss Development	Bornhuetter-Ferguson Using Ultimate Premiums and Paid Loss	Weights- Bornhuetter-Ferguson Using Ultimate Premiums and Paid Loss	Bornhuetter-Ferguson Using Ultimate Premiums and Incurred Loss	Weights- Bornhuetter-Ferguson Using Ultimate Premiums and Incurred Loss	Weighted Average	Default Selected	Manual Selected	Ultimate Loss
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
12-2011	$ 21,637	1.0000	$ 21,348	1.0000	$ 21,602	0.0000	$ 21,345	0.0000	$ 21,492	$ 21,492		$ 21,492
12-2012	14,658	1.0000	14,424	1.0000	14,676	0.0000	14,428	0.0000	14,541	14,541		14,541
12-2013	13,533	1.0000	13,327	1.0000	13,529	0.0000	13,327	0.0000	13,430	13,430		13,430
12-2014	8,979	1.0000	8,826	1.0000	8,992	0.0000	8,833	0.0000	8,902	8,902		8,902
12-2015	8,494	1.0000	8,343	1.0000	8,491	0.0000	8,345	0.0000	8,418	8,418		8,418
12-2016	7,224	1.0000	7,090	1.0000	7,246	0.0000	7,110	0.0000	7,157	7,157		7,157
12-2017	7,868	1.0000	7,817	1.0000	7,881	0.0000	7,831	0.0000	7,842	7,842		7,842
12-2018	11,506	1.0000	11,265	1.0000	11,258	0.0000	11,106	0.0000	11,386	11,386		11,386
12-2019	16,238	0.0000	15,831	0.0000	15,236	1.0000	15,075	1.0000	15,155	15,155		15,155
12-2020	15,821	0.0000	15,467	0.0000	13,909	1.0000	13,856	1.0000	13,883	13,883		13,883
Total	$ 125,958		$ 123,737		$ 122,819		$ 121,255		$ 122,207	$ 122,207		$ 122,207

For example, to reference the weights associated with the Paid Loss Development method in column (2), we created DATA | USER DEFINED | **#607 Historical Weights – Paid Loss Development** as follows:



- The first parameter in the GetWeights() function represents the formula-driven assumption array or the ultimate array corresponding to the Comparison of Ultimate Loss report, e.g., Ultimate Loss.
- The second parameter references the Calculated Ultimate from the method or input array that may be included in the object represented by the first parameter.
- Note: the suffix of (ULT) is needed to distinguish this table from the Paid Loss Development exhibit.

For more information on the GetWeights() function, refer to the document “Formula functions” found in Arius under HELP | USER DOCUMENTATION.