DecL Cheat Sheet for Compound Distributions

The DecL specification of an `Aggregate` compound distribution object has eight clauses:

`agg <NAME> <EXPOSURE> <LIMIT*> <SEVERITY> <OCC_RE*> <FREQUENCY> <AGG_RE*> <NOTE*>`

Key: `<INPUT>` denotes user input(s); clauses marked with an asterisk are optional; `lower_case` is a DecL keyword; `CLAUSE_TYPE` is a valid clause; options: `a|b|c`.

1. Name Clause

```
agg NAME
```

Name of the compound
Access from knowledge as `agg.NAME`.
Names must match regex
`r'[a-zA-Z][\._: a-zA-Z0-9\-]*'`.

2. Exposure Clause

```
<EXP_LOSS> loss
<PREMIUM> premium at <LR> lr
<EXPOSURE> exposure at <RATE> rate
<CLAIMS> claims
dfreq <OUTCOMES> <PROBABILITIES*>
```

Outcomes entered `[1 2 3 4]` or `[2:10:2]` and probabilities `[.5 .25 1/8 1/9]` or omitted for equally likely.

3. Limit Clause (optional)

```
<LIMIT> xs <ATTACHMENT>
```

Occurrence limits applied to ground-up severity, unlimited reinstatements, losses conditional on attaching layer by default.

4. Severity Clause

```
sev <DIST_NAME> <MEAN> cv <CV>
sev <DIST_NAME> <SHAPE1> <SHAPE2>
dsev <OUTCOMES> <PROBABILITIES>
```

`<SCALE> * SEV + <LOC>`.

`SEV splice [<LB> <UB>]` *conditional in layer*

`SEV !` *unconditional, when* `ATTACHMENT` *> 0*

5. Occurrence Reinsurance Clause

```
occurrence ceded to LAYERS
occurrence net of LAYERS
LAYER=SHARE so LAYER xs ATTACH |
PARTICIPATION po LAYER xs ATTACH
LAYERS=LAYER1 and LAYER2 and ...
```

Amount share of (`so`); participation (placed) $0 \le po \le 1$ part of (`po`)

```
LAYERS=tower[250 500 1000]
```

Specify layer breaks, expands to `250 xs 0`, `250 xs 250`, and `500 xs 500`; ground-up layer automatically added.

6. Frequency Clause

`poisson`, `bernoulli`, `fixed`, `geometric`,
`logarithmic`, `binomial XX`, `negbin var_mult`,
`pascal XX XX`, `neymana XX`

```
mixed <MIXING DIST> <SHAPE1> <SHAPE2>
MIXING DIST=gamma|delaporte|ig|sichel|beta
FREQ zt
FREQ zm p0
```

zero truncated, zero modified with $\Pr(N = 0) = p0$

7. Aggregate Reinsurance Clause

```
aggregate ceded to LAYERS
aggregate net of LAYERS
aggregate (net of|ceded to) tower [<BREAKS>]
```

8. Note

```
note{prems op A curve, effective 1/1/2024;}
note{bs=100; log2=17; normalize=False}
```

Add hints for updating

9. Vectorization

Exposure clause
```
[1 2 3] claims
[100 200 300] loss
[100 200 300] premium at [.8 .7 .65] lr
```
Layers clause
`[250 250 500] xs [0 250 500]` *zip layers*
Severity clause
```
[1 3] * expon 1 wts [.6 .4]
[1 3] * [gamma lognorm] [4 1.25] wts [.6 .4]
```
Vectors are broadcast; layers, exposure etc. are zipped.

10. Mathematical Expressions

Only division, exponentiation, and exponential allowed
`123`, `12.34e2`, `-12.4e-5`, `-12.0`, `12.4%`
`1/2`, `3**4`, `exp(2)`
Warning: *there is no unary minus, minus binds to the number:* $-4^2 = (-4)^2 = 16$.
Scale factor for lognormal μ, σ *entered as*
`exp(mu)/exp(sigma**2/2)`.

Notes:

`aggregate 0.18.0`
2023-07-16

Aggregate Class Cheat Sheet

The Aggregate call signature follows the corresponding DecL clauses, using prefixes for exposure (including limit sub-clause), severity, occurrence reinsurance, frequency, aggregate reinsurance, and note. sev_xs, sev_ps equal dsev outcomes and probabilities, and (occ|agg)_reins clauses are lists of (share, limit, attachment) triples.

```
ⓜ Aggregate(name, exp_el=0, exp_premium=0, exp_lr=0, exp_en=0, exp_attachment=0, exp_limit=np.inf,
  sev_name=", sev_a=np.nan, sev_b=0, sev_mean=0, sev_cv=0, sev_loc=0, sev_scale=0, sev_xs=None, sev_ps=None, sev_wt=1, sev_conditional=True,
  occ_reins=None, occ_kind=", freq_name=", freq_a=0, freq_b=0, freq_zm=False, freq_p0=np.nan, agg_reins=None, agg_kind=", note=")[0]
```

The following tables show all ⓜ methods, and fields or properties (used interchangeably). Comments elucidate the meaning of more obscure entries.

1. Specification & creation

name, limit, attachment, freq_name, freq_a, freq_b, freq_p0, freq_zm, note, sev_pick_attachments, sev_pick_losses, program (DecL program), pprogram (pretty printed), spec (constructor kwarg dictionary; Aggregate(**spec) re-creates the object), spec_ex (adds meta elements)

2. Update

log2, bs, sev_calc (discrete=round, forward, backwards), discretization_calc (distribution, survival, both), normalize, padding, tilt_vector, approximation (exact, slognorm, sgamma), fzapprox (frozen approximation rv), ⓜ picks, ⓜ discretize, ⓜ easy_update, ⓜ recommend_bucket, ⓜ rescale (homogeneous severity or inhomogeneous frequency rescaling), ⓜ update, ⓜ update_work

3. Moments

est prefix=estimated from FFT approximation

agg_m, agg_cv, agg_sd, agg_var, agg_skew, est_m, est_cv, est_sd, est_var, est_skew, sev_m, sev_cv, sev_sd, sev_var, sev_skew, est_sev_m, est_sev_cv, est_sev_sd, est_sev_var, est_sev_skew, ⓜ freq_moms, ⓜ freq_pmf, ⓜ freq_pgf, panjer_ab (Panjer parameters), ⓜ prn_eq_0 (Pr($N = 0$) unmodified), n (frequency), en (vector), unmodified_mean (when ZT or ZM)

4. Statistical functions

sevs (list of Severity s), ⓜ cdf, ⓜ sf (survival), ⓜ pdf, ⓜ pmf, ⓜ q (lower quantile=VaR), ⓜ tvar, ⓜ sev (exact severity cdf, sf, pdf), ⓜ q_sev, ⓜ tvar_sev, ⓜ var_dict[1], ⓜ sample

5. Validation

describe (validation statistics), valid (true="not unreasonable" or false), validation_eps (validation epsilon threshold 1e-04), ⓜ qt ("quick test" validation details), ⓜ aggregate_error_analysis (agg errors over range of bs), ⓜ severity_error_analysis (truncation and discretization errors by severity component)

6. Output dataframes

density_df[1] (main output), report_df (component, mixture & empirical stats), agg_density, agg_density_ceded, agg_density_gross, agg_density_net, sev_density, sev_density_ceded, sev_density_gross, sev_density_net, ftagg_density, xs, statistics_df (row, by component), statistics_total_df (row, indep. vs. mixed), statistics (cols, combined, better index), audit_df (deprecated), report_ser (internal, series), *see also Reinsurance.*

7. Reinsurance

agg_kind (net of or ceded to), agg_reins (list), agg_reins_df (gcn loss and dists), occ_kind, occ_reins, occ_reins_df, ⓜ agg_ceder, ⓜ agg_netter, ⓜ apply_agg_reins, ⓜ occ_ceder, ⓜ occ_netter, ⓜ apply_occ_reins, ⓜ reinsurance_description (text rendering of re), reinsurance_kinds (None, occ, agg, occ & agg), reinsurance_audit_df (stats by gcn, splits severity for occ), reinsurance_occ_layer_df (aggregate gcn stats for occ layers), reinsurance_df (all combinations of gcn occ and agg densities), reinsurance_report_df (m, cv, sd, skew for reinsurance_df)

8. Visualization

ⓜ plot, ⓜ reinsurance_occ_plot figure (return last figure), ⓜ limits (suggest axis limits for plotting),

9. Risk and pricing

ⓜ apply_distortion, ⓜ price(p, dist) ⓜ cramer_lundberg aka pollaczeck_khinchine (probability of eventual ruin vs. initial capital and margin)

10. Approximations

Method of moments (shifted gamma or lognormal), or minimum entropy approximations.

ⓜ approximate, ⓜ entropy_fit

11. Meta

aggregate_keys (internal), ⓜ more(regex) (print all methods and fields matching regex), info (text meta info), ⓜ html_info_blob (internal), ⓜ json (persist to json), ⓜ snap[1] (snap argument to index)

Notes:

[0]: Arguments sev_pick_attachments=None, sev_pick_losses=None, omitted; see help.

[1]: matches Portfolio

Any vectorizable input accepts numeric or iterable datatypes.

Abbreviations: gcn=gross (subject), ceded, and net; stats: m=mean, cv=coefficient of variation, sd=standard deviation, var=variance, skew(ness); VaR=value-at-risk

aggregate 0.18.0
2023-07-16

`Portfolio` Class Cheat Sheet

The `Portfolio` call signature is straightforward. `spec_list` is a DecL program, list of `Aggregate` objects or kwargs, or names known to the Underwriter, or a pandas DataFrame sample.

m `Portfolio(self, name, spec_list, uw=None)`

The following tables show all m `methods`, s `static methods`, and fields or properties (used interchangeably). Comments elucidate the meaning of more obscure entries. Internal methods and fields are not shown.

1. Specification & creation

`name`, `n_units`, `agg_list` (list of `Aggregate` objects), `line_names`, `line_names_ex`, `unit_names` (unit ← line), `unit_names_ex`, `line_name_pipe`, `program` (DecL program), `pprogram` (pretty printed), `spec` (constructor kwarg dictionary; `Aggregate(**spec)` re-creates the object), `spec_ex` (adds meta information), m `nice_program`, s `from_DataFrame`, s `from_dict_of_aggs`, s `from_Excel`, s `create_from_sample`

2. Update

`log2`, `bs`, `sev_calc` (discrete=round, forward, backwards), `discretization_calc` (distribution, survival, both), `normalize`, `padding`, `tilt_amount`, `approx_freq_ge`, `approx_type` (exact, slognorm, sgamma), m `best_bucket`, m `recommend_bucket`, m `update`, m `add_exa`, m `add_exa_details`, m `add_exa_sample`, m `trim_df`, m `ft` & m `ift` (FFT and inverse FFT), m `remove_fuzz`, m `set_a_p`

3. Moments

`est` prefix=estimated from FFT approximation

`agg_m`, `agg_cv`, `agg_sd`, `agg_var`, `agg_skew`, `est_m`, `est_cv`, `est_sd`, `est_var`, `est_skew`, `ex`

4. Statistical functions

m `cdf`, m `sf` (survival), m `pdf`, m `pmf`, m `q` (lower quantile=VaR), m `tvar`, m `tvar_threshold`, m `var`, m `var_dict`, m `density_sample`, m `percentiles`, m `sample`, m `sample(_density)_compare`,

5. Validation

`describe` (validation statistics), `valid` (true=all components and total "not unreasonable" or false), `validation_eps` (validation epsilon threshold 1e-04), m `audits`, m `uat`, m `uat_differential`, m `uat_interpolation_functions`

6. Output dataframes

`density_df`[1] (main output), `report_df` (component, mixture & empirical stats), `statistics`, `statistics_df`, `audit_df`, `augmented_df`, `independent_audit_df`, `independent_density_df`, `priority_analysis_df`, m `make_audit_df`, m `make_all`, m `report`

7. Reinsurance

None – applies at the component level

8. Visualization & exhibits

m `plot`, m `scatter`, m `twelve_plot`, m `biv_contour_plot`, m `analyze_distortion_plots`, m `natural_profit_segment_plot`, m `profit_segment_plot`, `figure` (return last figure), m `limits`, `line_renamer`, `premium_capital_renamer`, `renamer`, m `short_renamer`, `stat_renamer`, `tm_renamer`, m `show_enhanced_exhibits`, `EX_accounting_economic_balance_sheet`, `EX_multi_premium_capital`, `EX_premium_capital`

9. Risk and pricing

m `accounting_economic_balance_sheet`, m `analysis_collateral`, m `analysis_priority`, m `analyze_distortion(s|_add_comps)`, m `apply_distortion(s)`, `assets_2_epd`, m `bodoff`, m `calibrate_blends`, m `calibrate_distortion(s)`, m `cotvar`, `dist_ans`, `distortion`, `distortion_df`, `dists`, `epd_2_assets`, m `equal_risk_epd`, m `equal_risk_var_tvar`, m `gamma`, m `gradient`, m `merton_perold`, m `multi_premium_capital`, m `premium_capital`, m `price`, m `price_ccoc`, m `pricing_bounds`, `priority_capital_df`, m `stand_alone_pricing`,

10. Approximations

m `approximate`, m `as_severity`, m `collapse`

11. Meta

`audit_percentiles`, `hash_rep_at_last_update`, `info` (text meta info), m `json` (persist to json), `last_update`, m `more(regex)` (print all methods and fields matching regex), m `save`, m `snap`[1] (snap argument to index)

Notes:

[1]: matches `Aggregate`

Any vectorizable input accepts numeric or iterable datatypes.

Abbreviations: gcn=gross (subject), ceded, and net; stats: m=mean, cv=coefficient of variation, sd=standard deviation, var=variance, skew(ness); VaR=value-at-risk

`aggregate 0.18.0`
2023-07-16

Severity Class Cheat Sheet

The Severity call signature, sev_xs, sev_ps equal dsev outcomes and probabilities,

```
m Severity(name, sev_name=", sev_a=np.nan, sev_b=0, sev_mean=0, sev_cv=0, sev_loc=0, sev_scale=0, sev_xs=None, sev_ps=None,
           sev_wt=1, sev_lb, sev_ub, sev_conditional=True)
```

The following tables show all m methods, and fields or properties (used interchangeably). Comments elucidate the meaning of more obscure entries.

1. Specification & creation

a, attachment, b, badvalue, conditional, detachment, extradoc, limit, long_name, name, note, numargs, program, sev_loc, sev_name, sev_wt, shapes,

2. Update

m cv_to_shape, m mean_to_scale, pattach, pdetach,

3. Moments

m generic_moment, m mean, m median, m moment, m moment_type, m moms, sev1, sev2, sev3, m stats, m std, m support, m var,

4. Statistical functions

m cdf, m entropy, m expect, m interval, m isf, m logcdf, m logpdf, m logsf, m nnlf, m pdf, m ppf, m rvs, m sf, m vecentropy,

5. Validation

None

6. Output dataframes

None

7. Reinsurance

None

8. Visualization

m plot,

9. Risk and pricing

None

10. Approximations

m fit, m fit_loc_scale, m freeze,

11. Meta

fz, random_state, xtol,

Notes:

[0]: Arguments sev_pick_attachments=None, sev_pick_losses=None, omitted; see help.

[1]: matches Portfolio

Any vectorizable input accepts numeric or iterable datatypes.

Abbreviations: gcn=gross (subject), ceded, and net; stats: m=mean, cv=coefficient of variation, sd=standard deviation, var=variance, skew(ness); VaR=value-at-risk

aggregate 0.18.0
2023-07-16

`Underwriter` Class Cheat Sheet

The `Underwriter` call signature follows the corresponding DecL clauses, using prefixes for exposure (including limit sub-clause), severity, occurrence reinsurance, frequency, aggregate reinsurance, and note. `sev_xs, sev_ps` equal `dsev` outcomes and probabilities, and `(occ|agg)_reins` clauses are lists of (share, limit, attachment) triples.

m `Severity(name, exp_el=0, exp_premium=0, exp_lr=0, exp_en=0, exp_attachment=0, exp_limit=np.inf, sev_name='', sev_a=np.nan, sev_b=0, sev_mean=0, sev_cv=0, sev_loc=0, sev_scale=0, sev_xs=None, sev_ps=None, sev_wt=1, sev_conditional=True, occ_reins=None, occ_kind='', freq_name='', freq_a=0, freq_b=0, freq_zm=False, freq_p0=np.nan, agg_reins=None, agg_kind='', note='')`[0]

The following tables show all m `methods`, and fields or properties (used interchangeably). Comments elucidate the meaning of more obscure entries.

1. Specification & creation

None

2. Update

`knowledge`, `lexer`, `log2`, `parser`, m `read_database`, m `read_databases`, m `safe_lookup`, `update`, m `write`, m `write_from_file`,

3. Moments

None

4. Statistical functions

None

5. Validation

m `interpret_program`, m `interpreter_file`, m `interpreter_line`, m `interpreter_list`, m `interpreter_test_suite`, m `test_suite`,

6. Output dataframes

None

7. Reinsurance

None

8. Visualization

None

9. Risk and pricing

None

10. Approximations

None

11. Meta

m `build`, `case_dir`, `databases`, `debug`, `default_dir`, m `dir`, m `factory`, m `logger_level`, m `more`, `name`, m `qlist`, m `qshow`, m `show`, `site_dir`, `template_dir`, `test_suite_file`, `version`,

Notes:

[0]: Arguments `sev_pick_attachments=None, sev_pick_losses=None,` omitted; see help.

[1]: matches `Portfolio`

Any vectorizable input accepts numeric or iterable datatypes.

Abbreviations: gcn=gross (subject), ceded, and net; stats: m=mean, cv=coefficient of variation, sd=standard deviation, var=variance, skew(ness); VaR=value-at-risk

`aggregate 0.18.0`
2023-07-16

Distortion Class Cheat Sheet

The Distortion call signature follows the corresponding DecL clauses, using prefixes for exposure (including limit sub-clause), severity, occurrence reinsurance, frequency, aggregate reinsurance, and note. sev_xs, sev_ps equal dsev outcomes and probabilities, and (occ|agg)_reins clauses are lists of (share, limit, attachment) triples.

m Severity(name, exp_el=0, exp_premium=0, exp_lr=0, exp_en=0, exp_attachment=0, exp_limit=np.inf, sev_name=", sev_a=np.nan, sev_b=0, sev_mean=0, sev_cv=0, sev_loc=0, sev_scale=0, sev_xs=None, sev_ps=None, sev_wt=1, sev_conditional=True, occ_reins=None, occ_kind=", freq_name=", freq_a=0, freq_b=0, freq_zm=False, freq_p0=np.nan, agg_reins=None, agg_kind=", note=")[0]

The following tables show all m methods, and fields or properties (used interchangeably). Comments elucidate the meaning of more obscure entries.

1. Specification & creation

assets, m average_distortion, col_x, col_y, df, display_name, m distortions_from_params, has_mass, mass, name, premium_target, r0, m s_gs_distortion, shape,

2. Update

m bagged_distortion, error,

3. Moments

None

4. Statistical functions

m g, m g_dual, m g_inv, m g_prime, m wtd_tvar,

5. Validation

m test,

6. Output dataframes

None

7. Reinsurance

None

8. Visualization

m plot,

9. Risk and pricing

m price, m price2,

10. Approximations

None

11. Meta

m available_distortions, m convex_example, renamer,

Notes:

[0]: Arguments sev_pick_attachments=None, sev_pick_losses=None, omitted; see help.

[1]: matches Portfolio

Any vectorizable input accepts numeric or iterable datatypes.

Abbreviations: gcn=gross (subject), ceded, and net; stats: m=mean, cv=coefficient of variation, sd=standard deviation, var=variance, skew(ness); VaR=value-at-risk

aggregate 0.18.0
2023-07-16