

# Package ‘clmplus’

September 1, 2022

**Type** Package

**Title** Tool-Box of Chain Ladder + Models

**Version** 0.0.1

**Description** Implementation of the chain ladder model under the reverse time framework introduced in Hiabu (2017) <[doi:10.1080/03461238.2016.1240709](https://doi.org/10.1080/03461238.2016.1240709)>. It also implements extensions that add flexibility to the individual development factors modeling by allowing practitioners to set their own hazard rate model.

**URL** <https://github.com/gpitt71/clmplus>

**BugReports** <https://github.com/gpitt71/clmplus/issues>

**License** GPL (>= 2)

**Imports** StMoMo, ChainLadder, ggplot2, forecast, gridExtra, grid, reshape2

**Encoding** UTF-8

**LazyData** true

**Suggests** knitr, rmarkdown, apc, dplyr, tidyr

**VignetteBuilder** knitr, rmarkdown

**RoxygenNote** 7.2.1

**NeedsCompilation** no

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**Repository** CRAN

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amases.gtpl

*Amases GTPL*


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**Description**

Dataset of cumulative paid claims for a small italian company in the line of business: general third party liability.

**Usage**

```
amases.gtpl
```

**Format**

Run-off triangle with 12 development periods.

**References**

Savelli, Nino and Clemente, Gian Paolo. "Stochastic claim reserving based on crm for solvency ii purposes."

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`amases.mod`*Amases MOD*

---

**Description**

Dataset of cumulative paid claims for a small italian company in the line of business: motor or damage.

**Usage**`amases.mod`**Format**

Run-off triangle with 12 development periods.

**References**

Savelli, Nino and Clemente, Gian Paolo. "Stochastic claim reserving based on crm for solvency ii purposes."

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`amases.mtpl`*Amases MTPL*

---

**Description**

Dataset of cumulative paid claims for a small italian company in the line of business: motor third party liability.

**Usage**`amases.mtpl`**Format**

Run-off triangle with 12 development periods.

**References**

Savelli, Nino and Clemente, Gian Paolo. "Stochastic claim reserving based on crm for solvency ii purposes."

`clmplus`*Fit chain-ladder+ to reverse time triangles.*

---

**Description**

Generic method to fit the chain ladder +.

**Usage**

```
clmplus(RtTriangle, hazard.model = NULL, ...)
```

**Arguments**

<code>RtTriangle</code>	RtTriangle object to be fitted.
<code>hazard.model</code>	hazard model supported from our package, must be provided as a string. The model can be chosen from: <ul style="list-style-type: none"><li>• 'a': Age model, this is equivalent to the Mack chain-ladder.</li><li>• 'ac': Age and cohort effects.</li><li>• 'ap': Age and cohort effects.</li><li>• 'apc': Age cohort and period effects.</li><li>• 'cbd': Cairns-Blake-Dowd mortality model (CBD).</li><li>• 'm6': CBD with cohorts.</li><li>• 'm7': CBD m7 extension.</li><li>• 'm8': CBD m7 extension.</li></ul>
<code>...</code>	arguments to be passed to or from other methods.

**Value**

No return value, called to pass method `clmplus`.

**References**

Hiabu, Munir. "On the relationship between classical chain ladder and granular reserving." *Scandinavian Actuarial Journal* 2017 (2017): 708 - 729.

**Examples**

```
data(sifa.mtpl)
sifa.mtpl.rtt <- RtTriangle(cumulative.payments.triangle=sifa.mtpl)
hz.chl=clmplus(sifa.mtpl.rtt, 'a')
```

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clmplus.default	<i>Fit chain-ladder+ to reverse time triangles.</i>
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---

## Description

This function allows to fit chain-ladder+ models to cumulative payments run-off triangles.

## Usage

```
## Default S3 method:  
clmplus(RtTriangle, hazard.model = NULL, ...)
```

## Arguments

RtTriangle	RtTriangle object to be fitted.
hazard.model	hazard model supported from our package, must be provided as a string. The model can be chosen from: <ul style="list-style-type: none"><li>• 'a': Age model, this is equivalent to the Mack chain-ladder.</li><li>• 'ac': Age and cohort effects.</li><li>• 'ap': Age and cohort effects.</li><li>• 'apc': Age cohort and period effects.</li><li>• 'cbd': Cairns-Blake-Dowd mortality model (CBD).</li><li>• 'm6': CBD with cohorts.</li><li>• 'm7': CBD m7 extension.</li><li>• 'm8': CBD m7 extension.</li></ul>
...	parameters to be passed to clmplus.

## Value

No return value, called as clmplus method default.

## References

Hiabu, Munir. "On the relationship between classical chain ladder and granular reserving." *Scandinavian Actuarial Journal* 2017 (2017): 708 - 729.

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clmplus.RtTriangle      *Fit chain-ladder+ to reverse time triangles.*

---

## Description

This function allows to fit chain-ladder+ models to cumulative payments run-off triangles.

## Usage

```
## S3 method for class 'RtTriangle'
clmplus(
  RtTriangle,
  hazard.model = NULL,
  xc = NULL,
  iter.max = 10000,
  tolerance.max = 1e-06,
  link = c("log", "logit"),
  staticAgeFun = TRUE,
  periodAgeFun = "NP",
  cohortAgeFun = NULL,
  constFun = function(ax, bx, kt, b0x, gc, wxt, ages) list(ax = ax, bx = bx, kt = kt, b0x
    = b0x, gc = gc),
  ...
)
```

## Arguments

RtTriangle	RtTriangle object to be fitted.
hazard.model	hazard model supported from our package, must be provided as a string. The model can be chosen from: <ul style="list-style-type: none"> <li>• 'a': Age model, this is equivalent to the Mack chain-ladder.</li> <li>• 'ac': Age and cohort effects.</li> <li>• 'ap': Age and cohort effects.</li> <li>• 'apc': Age cohort and period effects.</li> <li>• 'cbd': Cairns-Blake-Dowd mortality model (CBD).</li> <li>• 'm6': CBD with cohorts.</li> <li>• 'm7': CBD m7 extension.</li> <li>• 'm8': CBD m7 extension.</li> </ul>
xc	xc constant parameter to be set for the m8 model. Default to NULL.
iter.max	maximum number of iterations for the Newton-Rhapson algorithm. It will be ignored for other fitting procedures.
tolerance.max	maximum tolerance of parameters difference for convergence for the Newton-Rhapson algorithm implementation. Ignored for other fitting procedures.

link	defines the link function and random component associated with the mortality model. "log" would assume that deaths follow a Poisson distribution and use a log link while "logit" would assume that deaths follow a Binomial distribution and a logit link. To be disregarded unless the practitioner specifies his own hazard model in StMoMo.
staticAgeFun	logical value indicating if a static age function $\alpha_x$ is to be included. To be disregarded unless the practitioner specifies his own hazard model in StMoMo.
periodAgeFun	a list of length $N$ with the definitions of the period age modulating parameters $\beta_x^{(i)}$ . Each entry can take values: "NP" for non-parametric age terms, "1" for $\beta_x^{(i)} = 1$ or a predefined parametric function of age (see details). Set this to NULL if there are no period terms in the model. To be disregarded unless the practitioner specifies his own hazard model in StMoMo.
cohortAgeFun	defines the cohort age modulating parameter $\beta_x^{(0)}$ . It can take values: "NP" for non-parametric age terms, "1" for $\beta_x^{(0)} = 1$ , a predefined parametric function of age (see details) or NULL if there is no cohort effect. To be disregarded unless the practitioner specifies his own hazard model in StMoMo.
constFun	function defining the identifiability constraints of the model. It must be a function of the form <code>constFun &lt;- function(ax, bx, kt, b0x, gc, wxt, ages)</code> taking a set of fitted model parameters and returning a list <code>list(ax = ax, bx = bx, kt = kt, b0x = b0x, gc = gc)</code> of the model parameters with the identifiability constraints applied. If omitted no identifiability constraints are applied to the model. To be disregarded unless the practitioner specifies his own hazard model in StMoMo.
...	extra arguments to be passed from or to other methods.

### Value

An object of class "clmplusmodel". A list with the following elements:

model.fit	Hazard model fit from StMoMo.
hazard.model	Hazard model chosen.
exposure	Matrix that contains the exposure derived from the input triangle, under the uniform claims arrival assumption.
ultimate.cost	Ultimate costs vector.
model.fcst	Hazard forecasts.
converged	logical value. Whether the fit converged.
citer	Number of Netwon-Rhapson iterations in case a lee-carter hazard-model was chosen.

### References

Hiabu, Munir. "On the relationship between classical chain ladder and granular reserving." *Scandinavian Actuarial Journal* 2017 (2017): 708 - 729.

## Examples

```
data(sifa.mtpl)
sifa.mtpl.rtt <- RtTriangle(cumulative.payments.triangle=sifa.mtpl)
hz.chl=clmplus(sifa.mtpl.rtt, 'a')
```

---

plot.clmplusmodel      *Plot the hazard model fitted and forecasted parameters*

---

## Description

This function allows to define the behavior of the triangle payments.

## Usage

```
## S3 method for class 'clmplusmodel'
plot(x, ...)
```

## Arguments

x	clmplus model to be plotted.
...	Arguments to be passed to plot.

## Value

No return value, plots coefficients of the hazard models.

## References

Hiabu, Munir. "On the relationship between classical chain ladder and granular reserving." *Scandinavian Actuarial Journal* 2017 (2017): 708 - 729.

## Examples

```
data(sifa.mtpl)
sifa.mtpl.rtt <- RtTriangle(cumulative.payments.triangle=sifa.mtpl)
hz.chl<-clmplus(sifa.mtpl.rtt, 'a')
plot(hz.chl)
```



---

plot.RtTriangle      *Plot the payments behavior*

---

**Description**

This function allows to define the behavior of the triangle payments.

**Usage**

```
## S3 method for class 'RtTriangle'  
plot(x, ...)
```

**Arguments**

x                      RtTriangle to be plotted.  
...                     Arguments to be passed to plot.

**Value**

No return value, plots the run-off triangle cumulative payments and incremental payments.

**References**

Hiabu, Munir. "On the relationship between classical chain ladder and granular reserving." *Scandinavian Actuarial Journal* 2017 (2017): 708 - 729.

**Examples**

```
data(sifa.mtpl)  
sifa.mtpl.rtt <- RtTriangle(cumulative.payments.triangle=sifa.mtpl)  
plot(sifa.mtpl.rtt)
```

---

plotresiduals      *Plot the hazard model residuals*

---

**Description**

This function allows to plot the hazard model residuals on the triangle payments.

**Usage**

```
plotresiduals(cImplusmodel, heat.lim = c(-2.5, 2.5))
```

**Arguments**

clmplusmodel    clmplusmodel object to be plotted.  
heat.lim        limits in the residuals plot.

**Value**

No return value, called to pass method plotresiduals.

**References**

Hiabu, Munir. "On the relationship between classical chain ladder and granular reserving." *Scandinavian Actuarial Journal* 2017 (2017): 708 - 729.

**Examples**

```
data(sifa.mtpl)
sifa.mtpl.rtt <- RtTriangle(cumulative.payments.triangle=sifa.mtpl)
hz.chl<-clmplus(sifa.mtpl.rtt, 'a')
plotresiduals(hz.chl)
```

---

plotresiduals.clmplusmodel

*Plot the hazard model residuals*

---

**Description**

This function allows to plot the hazard model residuals on the triangle payments.

**Usage**

```
## S3 method for class 'clmplusmodel'
plotresiduals(clmplusmodel, heat.lim = c(-2.5, 2.5))
```

**Arguments**

clmplusmodel    clmplusmodel object to be plotted.  
heat.lim        limits in the residuals plot.

**Value**

No return value, plots the hazard model residuals in triangular form.

**References**

Hiabu, Munir. "On the relationship between classical chain ladder and granular reserving." *Scandinavian Actuarial Journal* 2017 (2017): 708 - 729.

**Examples**

```
data(sifa.mtpl)
sifa.mtpl.rtt <- RtTriangle(cumulative.payments.triangle=sifa.mtpl)
hz.chl<-clmplus(sifa.mtpl.rtt, 'a')
plotresiduals(hz.chl)
```

---

plotresiduals.default *Plot the hazard model residuals*

---

**Description**

This function allows to plot the hazard model residuals on the triangle payments.

**Usage**

```
## Default S3 method:
plotresiduals(clmplusmodel, heat.lim = c(-2.5, 2.5))
```

**Arguments**

clmplusmodel	clmplusmodel object to be plotted.
heat.lim	limits in the residuals plot.

**Value**

No return value, called as plotresiduals method default.

**References**

Hiabu, Munir. "On the relationship between classical chain ladder and granular reserving." *Scandinavian Actuarial Journal* 2017 (2017): 708 - 729.

**Examples**

```
data(sifa.mtpl)
sifa.mtpl.rtt <- RtTriangle(cumulative.payments.triangle=sifa.mtpl)
hz.chl<-clmplus(sifa.mtpl.rtt, 'a')
plotresiduals(hz.chl)
```

---

RtTriangle

*Reverse time triangles*


---

**Description**

This function allows to define the class of triangles for reverse time models.

**Usage**

```
RtTriangle(cumulative.payments.triangle)
```

**Arguments**

```
cumulative.payments.triangle
```

Input triangle of cumulative payments.

**Value**

An object of class "RtTriangle". Lists the following elements:

```
cumulative.payments.triangle
```

Input triangle of cumulative payments.

```
occurrence
```

Matrix that contains the occurrence derived from the input triangle.

```
exposure
```

Matrix that contains the exposure derived from the input triangle, under the uniform claims arrival assumption.

```
incremental.payments.triangle
```

Triangle of incremental payments derived from the input.

```
J
```

Run-off triangle dimension.

```
diagonal
```

Cumulatives payments last diagonal.

**References**

Hiabu, Munir. "On the relationship between classical chain ladder and granular reserving." *Scandinavian Actuarial Journal* 2017 (2017): 708 - 729.

**Examples**

```
data(sifa.mtpl)
sifa.mtpl.rtt <- RtTriangle(cumulative.payments.triangle=sifa.mtpl)
```

---

sifa.gtpl

*Sifa GTPL*

---

**Description**

Dataset of cumulative paid claims for a medium italian company in the line of business: general third party liability.

**Usage**

sifa.gtpl

**Format**

Run-off triangle with 12 development periods.

**References**

Savelli, Nino and Clemente, Gian Paolo. "Stochastic claim reserving based on crm for solvency ii purposes."

---

sifa.mod

*Sifa MOD*

---

**Description**

Dataset of cumulative paid claims for a medium italian company in the line of business: motor or damage.

**Usage**

sifa.mod

**Format**

Run-off triangle with 12 development periods.

**References**

Savelli, Nino and Clemente, Gian Paolo. "Stochastic claim reserving based on crm for solvency ii purposes."

---

sifa.mtpl

*Sifa MTPL*

---

**Description**

Dataset of cumulative paid claims for a medium italian company in the line of business: motor third party liability.

**Usage**

sifa.mtpl

**Format**

Run-off triangle with 12 development periods.

**References**

Savelli, Nino and Clemente, Gian Paolo. "Stochastic claim reserving based on crm for solvency ii purposes."

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