# SOLVABILITE II : Utilisation de la methode de l'analyse en composantes principales pour la calibration du choc de la courbe de taux d'intérêts

2022-05-21

Interest rate term structure choc calibration using Principal component analysis (PCA) (Solvency II default calibration method)
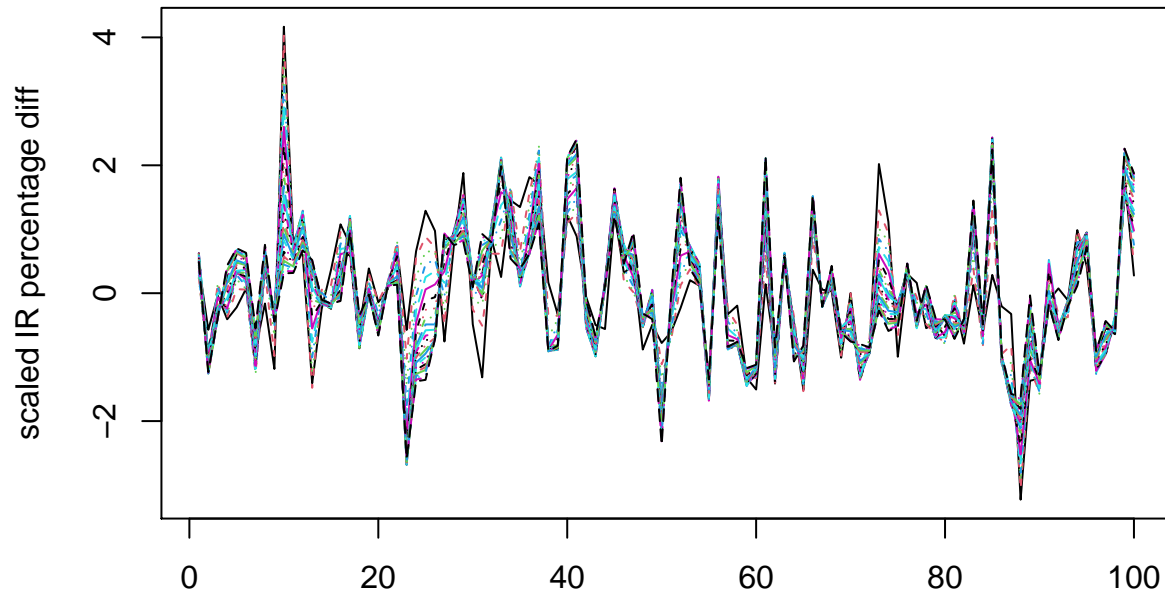
Aperçu des données : Taux d'évolutions journaliers des taux d'interets GLC par maturités

$$R\tau = \frac{\tau_{t+1}}{\tau_t} - 1$$
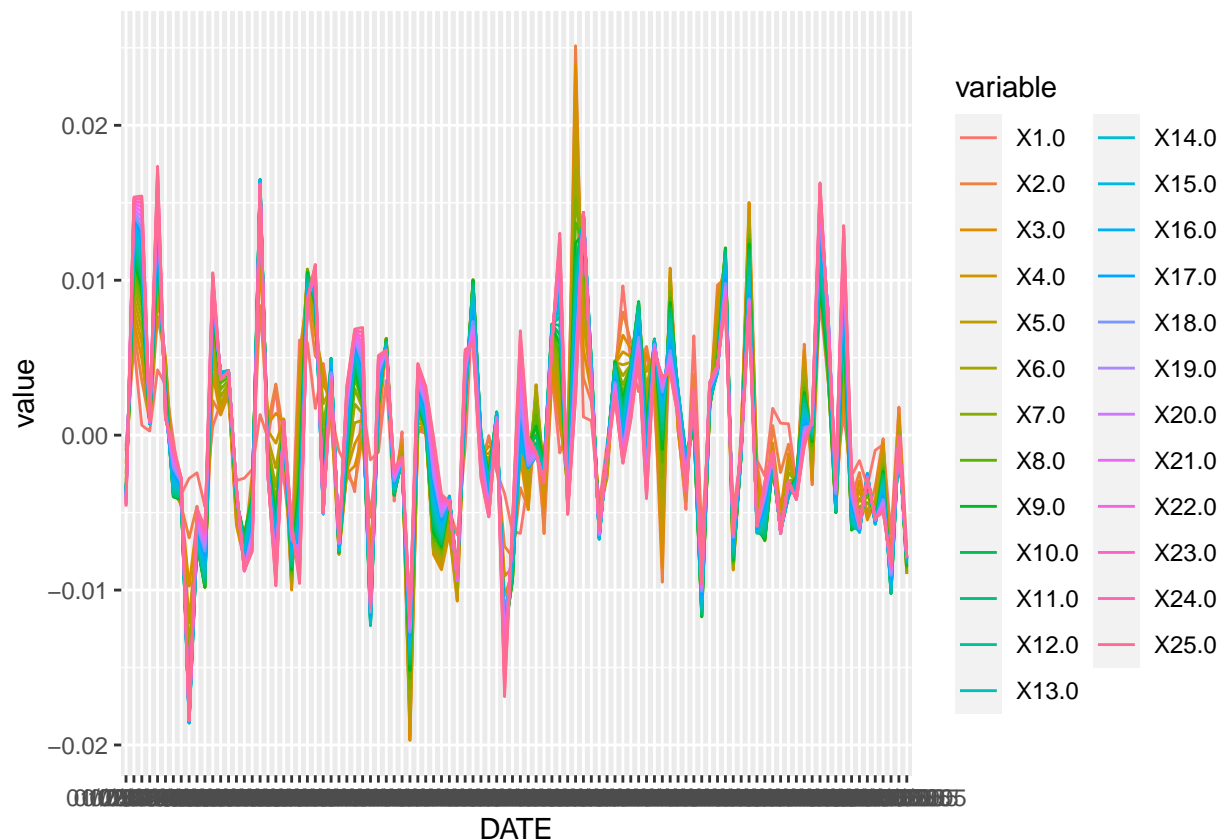
Aperçu des données : Taux d'évolutions journaliers des taux d'interets GLC par maturités centrées et réduites

$$R\tau_{cr} = \frac{R\tau - \mu}{\sigma}$$

Vecteurs propres et valeurs propres

```
## [1] "valeurs propres "
```

```
##  [1] 2.279204e+01 1.905393e+00 2.049214e-01 7.376064e-02 2.027382e-02
##  [6] 2.889866e-03 5.397106e-04 1.628857e-04 1.611769e-05 3.338597e-06
## [11] 6.776412e-07 2.010132e-07 3.315165e-08 7.404265e-09 5.362762e-09
## [16] 2.850525e-09 2.153782e-09 1.974813e-09 1.863799e-09 1.567279e-09
## [21] 1.319787e-09 1.244248e-09 1.231744e-09 8.812426e-10 8.191403e-10
```

```
## [1] "Vecteurs propres "
```

```
##              [,1]         [,2]        [,3]         [,4]          [,5]
## [1,] -0.1428876  0.488837994  0.49803155  0.597989595 -0.3193355343
## [2,] -0.1704815  0.410763125  0.23100847 -0.150619668  0.3567799411
## [3,] -0.1836943  0.339867705  0.08575632 -0.318684835  0.2950653412
## [4,] -0.1927381  0.276242143 -0.02085991 -0.316748446  0.0921573858
## [5,] -0.1990459  0.216337170 -0.10900036 -0.255534444 -0.1003994345
```

```
##  [6,] -0.2030811  0.161970356 -0.17854489 -0.173049222 -0.2322396817
##  [7,] -0.2054321  0.115262987 -0.22659184 -0.086808906 -0.2886221439
##  [8,] -0.2067375  0.076724390 -0.25239731 -0.005949092 -0.2739848626
##  [9,] -0.2074797  0.045210938 -0.25799377  0.064879223 -0.2053678714
## [10,] -0.2079188  0.018777037 -0.24685969  0.123119667 -0.1062038309
## [11,] -0.2081605 -0.004477208 -0.22268460  0.166756497  0.0008049302
## [12,] -0.2082410 -0.025922330 -0.18890323  0.193601096  0.0971892738
## [13,] -0.2081740 -0.046339009 -0.14845756  0.202624008  0.1713124013
## [14,] -0.2079586 -0.065981713 -0.10413151  0.195031739  0.2180084887
## [15,] -0.2075886 -0.084896680 -0.05813735  0.173259546  0.2365999625
## [16,] -0.2070575 -0.103002131 -0.01239884  0.140387829  0.2290467038
## [17,] -0.2063643 -0.120158114  0.03160537  0.100269798  0.1998934745
## [18,] -0.2055201 -0.136237148  0.07281323  0.056838052  0.1551396669
## [19,] -0.2045488 -0.151170007  0.11059456  0.013032469  0.1001303884
## [20,] -0.2034854 -0.164903767  0.14451445 -0.028880525  0.0394704643
## [21,] -0.2023642 -0.177476758  0.17445032 -0.067416072 -0.0232478026
## [22,] -0.2012185 -0.188951775  0.20038378 -0.101691398 -0.0849997662
## [23,] -0.2000783 -0.199388312  0.22247437 -0.131217125 -0.1436875099
## [24,] -0.1989706 -0.208841294  0.24080672 -0.155807740 -0.1982060353
## [25,] -0.1979129 -0.217396477  0.25559178 -0.175700183 -0.2475166876
##               [,6]         [,7]        [,8]         [,9]        [,10]
##  [1,] -0.15034720  0.068068038  0.070783632 -0.025955971  0.008329446
##  [2,]  0.52834097 -0.341715638 -0.379708970  0.209530978 -0.098098716
##  [3,]  0.05755445  0.174099473  0.423498170 -0.463978786  0.327941397
##  [4,] -0.27004423  0.273566822  0.231733618  0.127528387 -0.320809655
##  [5,] -0.34772975  0.133002192 -0.156593813  0.356969418 -0.140591013
##  [6,] -0.24327432 -0.064776602 -0.323088679  0.106408059  0.192150569
##  [7,] -0.06162287 -0.202926262 -0.223935150 -0.224201890  0.221443995
##  [8,]  0.10727408 -0.231358988 -0.001687368 -0.314262381  0.021294014
##  [9,]  0.21418608 -0.157892578  0.195460122 -0.141420216 -0.180737449
## [10,]  0.24704496 -0.024522929  0.269628458  0.108648909 -0.216935065
## [11,]  0.21738659  0.117606554  0.207306033  0.252437247 -0.081190092
## [12,]  0.14685133  0.217030057  0.064563299  0.240805856  0.097941703
## [13,]  0.05709557  0.245205128 -0.085965632  0.115409328  0.209976259
## [14,] -0.03191980  0.204687012 -0.186416193 -0.034440604  0.204508594
## [15,] -0.10672365  0.113088422 -0.211585378 -0.152500082  0.090476008
## [16,] -0.15824126 -0.004744248 -0.164930422 -0.203777935 -0.075854812
## [17,] -0.18332811 -0.120649181 -0.073407737 -0.180135747 -0.209096416
## [18,] -0.18254469 -0.209710533  0.028006896 -0.101841243 -0.249054667
## [19,] -0.15907031 -0.256929092  0.113831055  0.002154445 -0.171557760
## [20,] -0.11632168 -0.255662237  0.167412611  0.103347347 -0.020724060
## [21,] -0.05862621 -0.205554063  0.177262914  0.175293574  0.152668945
## [22,]  0.01027974 -0.108662913  0.137766600  0.189501158  0.271393084
## [23,]  0.08690954  0.030160391  0.049673536  0.128396419  0.280813767
## [24,]  0.16896181  0.205355432 -0.081698840 -0.018267048  0.085031432
## [25,]  0.25448691  0.410495314 -0.244623183 -0.257563412 -0.399048350
##              [,11]        [,12]         [,13]         [,14]         [,15]
##  [1,] -0.004373329  0.002799167 -0.0005033072  0.0001757034 -0.0003406288
##  [2,]  0.058282897 -0.039755874  0.0112277735 -0.0060682071  0.0097435490
##  [3,] -0.253092422  0.201846739 -0.0781314649  0.0418398784 -0.0755662838
##  [4,]  0.353731479 -0.426837913  0.2352378874 -0.1206441823  0.2651513891
##  [5,]  0.044746025  0.293970082 -0.3029579870  0.1755076340 -0.4984910328
##  [6,] -0.334868853  0.250907282  0.0006408230 -0.1112183136  0.4799283466
##  [7,] -0.138152309 -0.316723070  0.3734544627 -0.0415742839 -0.0681614053
```

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##  [8,]  0.245357219 -0.250774031 -0.1330275894  0.1048144385 -0.3336821616
##  [9,]  0.272850908  0.156716335 -0.3408523209  0.0495315846  0.2009789895
## [10,] -0.003516161  0.324760179  0.0458514174 -0.2321820425  0.1825351218
## [11,] -0.227569188  0.085933774  0.3595599101  0.0753560901 -0.0746340933
## [12,] -0.229654283 -0.197337345  0.1256792510  0.2681397811 -0.2236107830
## [13,] -0.061890940 -0.261054702 -0.2693931906 -0.1164886273  0.0494299423
## [14,]  0.131170822 -0.108523641 -0.2758516211 -0.3425825642  0.0289696432
## [15,]  0.249610593  0.119336498 -0.0061328868  0.1057934383  0.1355395485
## [16,]  0.194618768  0.229543754  0.2034486236  0.3298020436  0.0832189749
## [17,] -0.003228466  0.144926632  0.2537353359  0.0775524378 -0.0742178394
## [18,] -0.173549534  0.012236310  0.0591283849 -0.2212564395 -0.1587608435
## [19,] -0.230467211 -0.103809382 -0.1259309130 -0.2854320954 -0.1173833701
## [20,] -0.175026500 -0.159008348 -0.1941355980 -0.0044837595  0.0857856339
## [21,] -0.010613059 -0.133953880 -0.1644387349  0.2372331368  0.1258495388
## [22,]  0.162126943 -0.006228446  0.0385590149  0.3585492872  0.1896859621
## [23,]  0.257234504  0.139693349  0.1894539431 -0.1925944343 -0.1517648749
## [24,]  0.161471147  0.169216902  0.1560705318 -0.3692839994 -0.1762020260
## [25,] -0.285044017 -0.127851911 -0.1606985661  0.2194912033  0.1160285654
##               [,16]         [,17]         [,18]         [,19]         [,20]
##  [1,] -5.578512e-06  0.0001293183 -1.137288e-05 -8.990863e-05  0.0001079629
##  [2,] -2.840787e-04 -0.0010535040  9.189744e-05  1.410851e-03 -0.0022294083
##  [3,]  1.811364e-03  0.0031148128 -1.919726e-03 -9.434225e-03  0.0180162710
##  [4,] -4.341162e-04 -0.0058993565  8.781348e-03  3.770662e-02 -0.0729681267
##  [5,] -2.175149e-02  0.0136335477 -1.293439e-02 -1.033440e-01  0.1851758046
##  [6,]  7.966911e-02 -0.0266426914 -1.508996e-02  2.015827e-01 -0.3367635944
##  [7,] -1.380228e-01  0.0103885931  9.833654e-02 -2.643238e-01  0.4575349935
##  [8,]  9.432972e-02  0.0938966647 -2.097679e-01  1.691422e-01 -0.4199176897
##  [9,]  1.175222e-01 -0.2548434600  2.695893e-01  9.614458e-02  0.1782461565
## [10,] -3.515429e-01  0.2728495562 -1.845040e-01 -2.708961e-01 -0.0055407494
## [11,]  3.936567e-01 -0.0623100275 -4.314814e-02  1.318763e-01  0.1890550529
## [12,] -3.524296e-01 -0.0323375767  1.977660e-01  2.428194e-02 -0.3952136727
## [13,]  3.182904e-01 -0.1655069819 -4.817067e-02  1.448733e-01  0.2260282414
## [14,] -1.735196e-02  0.1642380242 -2.805981e-01 -3.427702e-01 -0.0607221242
## [15,] -2.934214e-01  0.0968175361  4.341466e-01  3.171407e-01  0.0761756682
## [16,]  1.070368e-01  0.0164462454 -2.181902e-01 -2.110843e-01  0.0991678007
## [17,]  4.463717e-02 -0.4109124123 -1.472756e-01 -3.247279e-02 -0.1815992424
## [18,]  3.851717e-02  0.4068022470  1.297792e-01  1.875596e-01  0.0111598477
## [19,]  2.526495e-01  0.1116796163  2.161503e-01 -1.926436e-02 -0.0587184477
## [20,] -3.609597e-01 -0.4579903829 -3.520080e-01  8.294917e-02  0.0971022544
## [21,] -1.222387e-01  0.0643008066  2.944057e-01 -2.386152e-01  0.0712379087
## [22,]  3.215740e-01  0.2652428180 -9.255526e-02 -1.603922e-01 -0.1379528556
## [23,] -1.575407e-01  0.1105491385 -2.562220e-01  5.014991e-01  0.1994368740
## [24,]  8.501477e-02 -0.3470523247  3.166718e-01 -2.908284e-01 -0.2226891697
## [25,] -3.873435e-02  0.1344754380 -1.033299e-01  4.734430e-02  0.0858794345
##               [,21]         [,22]         [,23]         [,24]         [,25]
##  [1,] -2.862861e-06  0.0001245468  0.0000163847 -4.722127e-07  3.642891e-05
##  [2,]  5.688253e-04 -0.0018197763 -0.0002309348 -4.882782e-04 -1.128739e-04
##  [3,] -4.741935e-03  0.0118180077  0.0022374185  3.451148e-03  5.668081e-04
##  [4,]  1.767895e-02 -0.0420706247 -0.0105276389 -7.019134e-03 -4.960883e-03
##  [5,] -3.990825e-02  0.0879008457  0.0328705321  2.551423e-03  1.722930e-02
##  [6,]  5.582548e-02 -0.1088425607 -0.0795806486 -3.036298e-03 -1.807344e-02
##  [7,] -2.352805e-02  0.0731748733  0.1540062763  5.517657e-02 -4.422701e-02
##  [8,] -9.274778e-02  0.0041772353 -0.2229647257 -1.501543e-01  1.940703e-01
##  [9,]  2.583295e-01 -0.0750479468  0.1896718024  1.523199e-01 -3.134622e-01
```

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```
## [10,] -3.839704e-01  0.0128362137  0.0248010202  2.595234e-02  1.632720e-01
## [11,]  3.189334e-01  0.2118701786 -0.2726931889 -1.848569e-01  1.902189e-01
## [12,]  1.025686e-01 -0.2174085648  0.2616435011  8.223304e-02 -2.222692e-01
## [13,] -5.830470e-01 -0.1450342260 -0.0426090663  5.648586e-02 -6.509926e-02
## [14,]  4.849065e-01  0.1716296559 -0.0569825053  1.222564e-01 -4.540359e-02
## [15,] -4.877691e-02  0.3468850843  0.0242145118 -2.068847e-01  3.120163e-01
## [16,]  3.428007e-02 -0.5618520557  0.0227421313 -3.076575e-01 -3.531831e-02
## [17,] -1.355160e-01  0.2520050064 -0.0374577912  5.949889e-01  3.837102e-02
## [18,] -7.553093e-02  0.0859162270 -0.2190643758 -1.031456e-01 -5.977943e-01
## [19,]  9.826041e-02 -0.2231144942  0.4402539249  1.720288e-02  4.730445e-01
## [20,]  5.032530e-02  0.1555090878  0.0436623554 -4.219391e-01 -4.675816e-02
## [21,]  4.109209e-02 -0.1979517100 -0.5939610542  2.411682e-01  1.551844e-01
## [22,] -1.331708e-01  0.3764901614  0.3512100951 -3.189249e-02 -1.494992e-01
## [23,]  1.168091e-01 -0.2481913507  0.0671081963  2.654911e-01  2.610063e-02
## [24,] -9.902094e-02 -0.0048677720 -0.0872935369 -2.755213e-01 -9.120962e-02
## [25,]  4.038861e-02  0.0358758961  0.0089301189  7.331562e-02  6.409157e-02
```
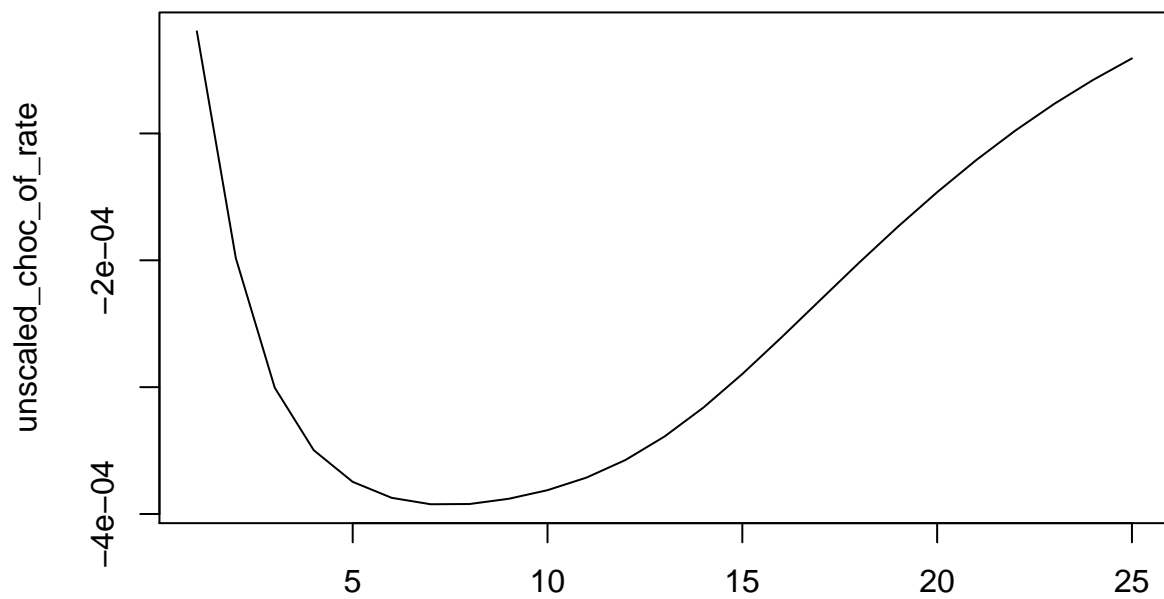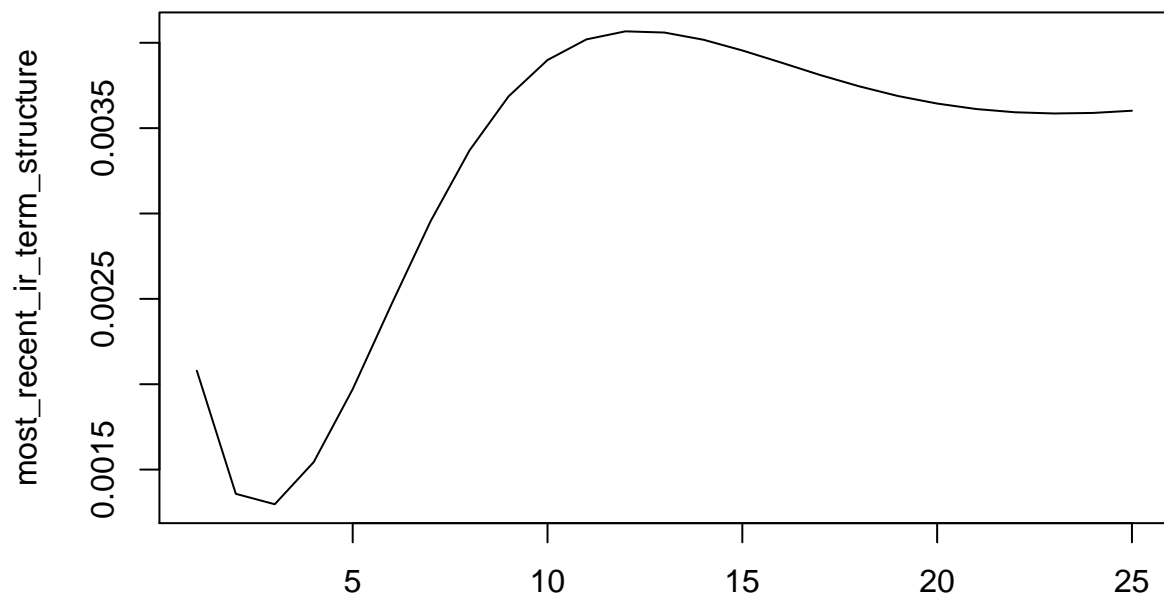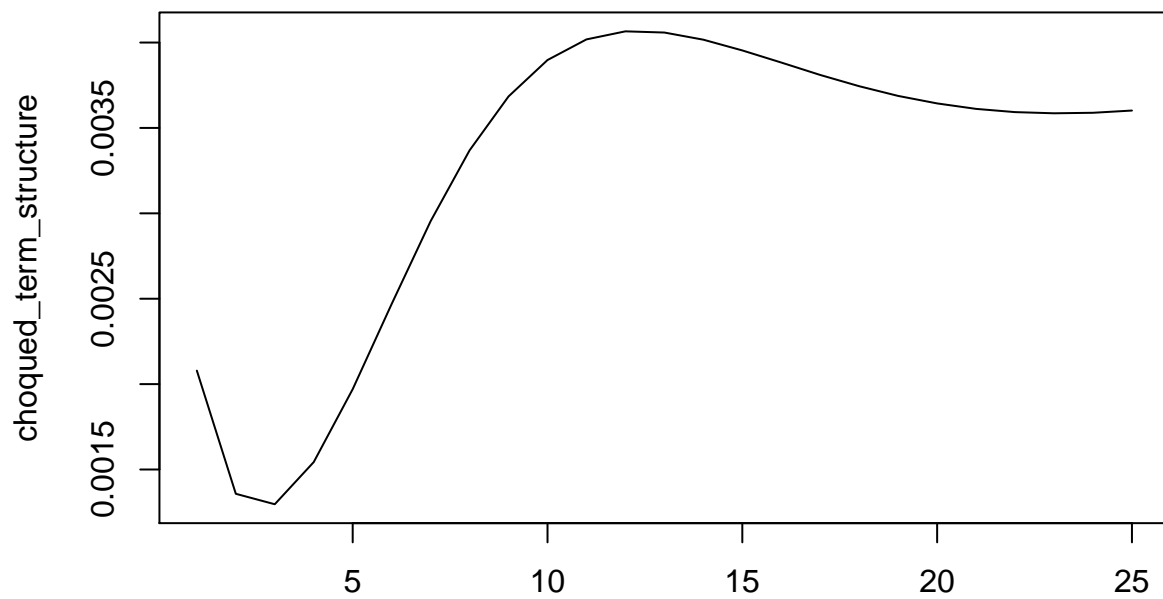
Graphique des trois premiers vecteurs propres
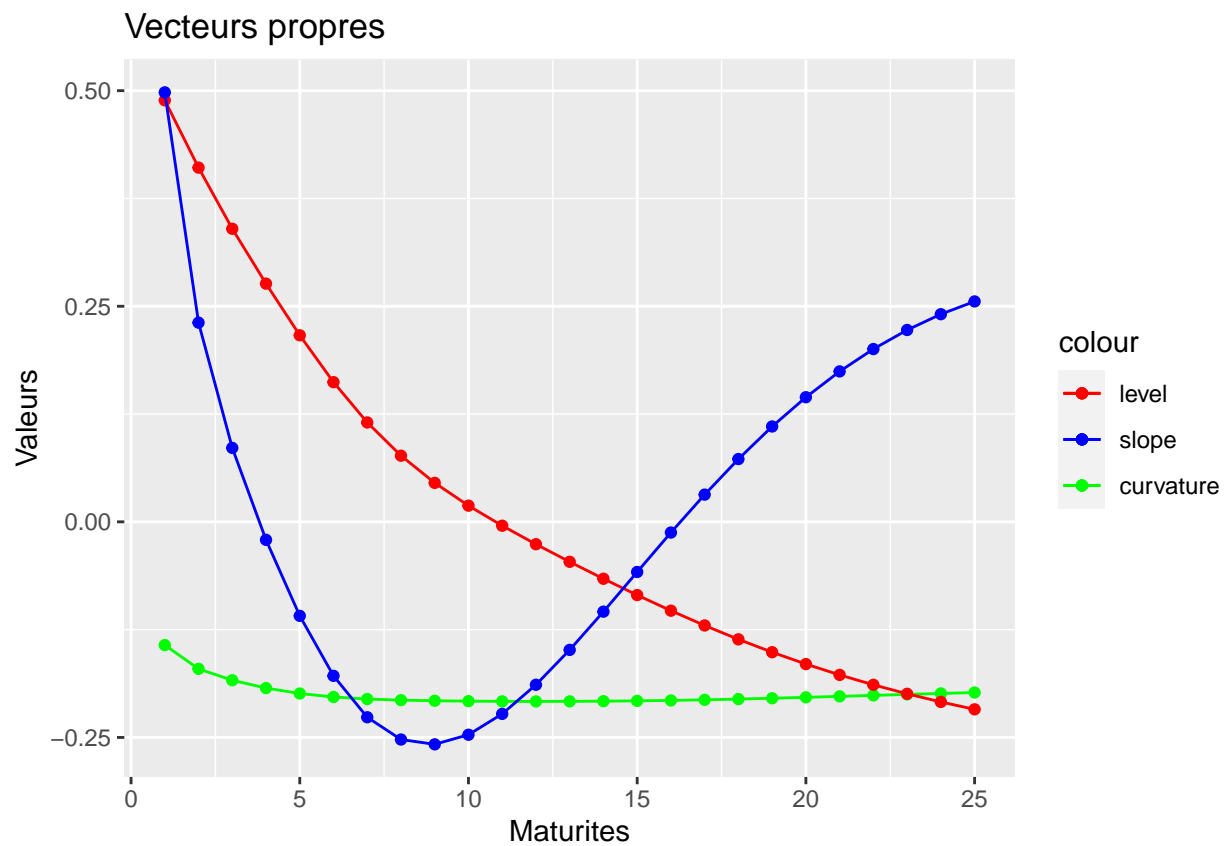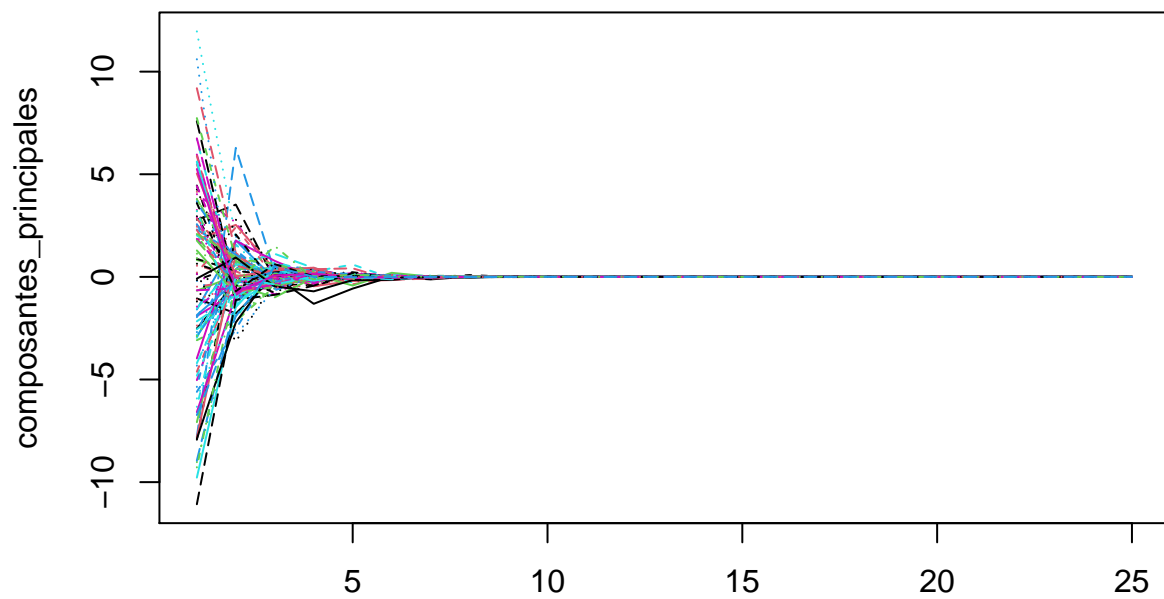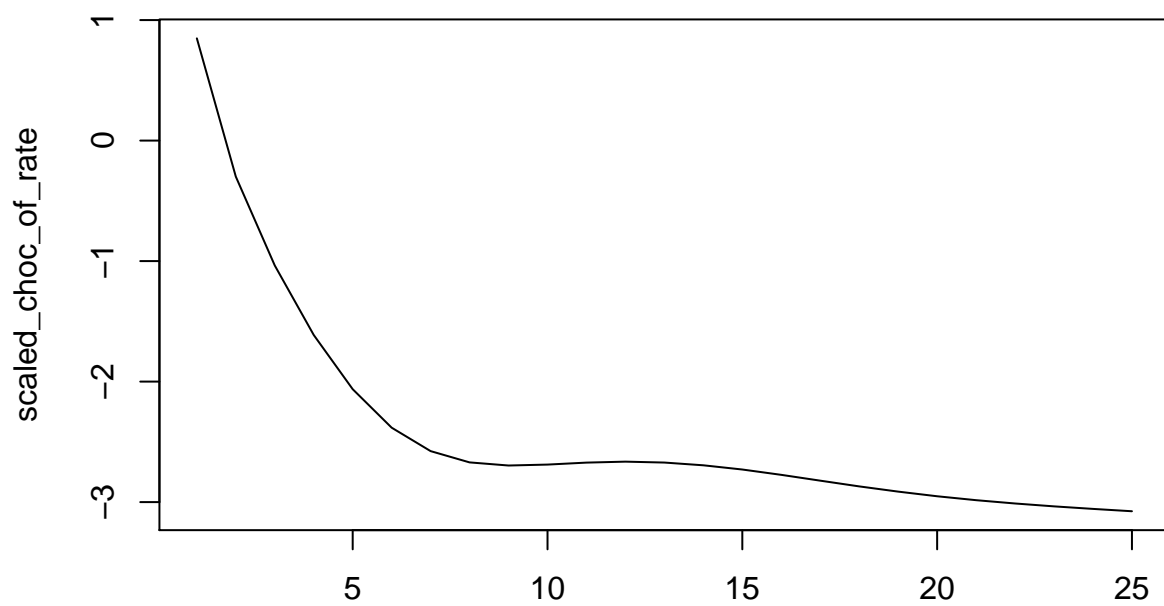
```
# Develop the shocked pc's and the rateShocks
# pcaShockUp <- pca$vectors * eigenGoodForm^.5 * qnorm(.995)
# rateShockUp <- (1+pcaShockUp*stdevRateGoodForm *sqrt(12))* lastRateGoodForm
```