Dados CEPEA

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Os dados são de peridiocidade diária e são disponibilizados pela CEPEA/EXALQ e se referem ao período de a 23/01/2017. O dados para o etanol correspondem ao Indicador Diário do Etanol Hidratado ESALQ/BM&FBovespa Posto Paulínia (SP). Para o açúcar os dados são o Indicado Açúcar Criatal CEPEA/EXALQ - São Paulo por saca de 50 quilos. Para o soja os dados são o Indicador Soja CEPEA/EXALQ - Paraná por saca de 60 quilos. Ocorreram 15 valores faltante para o soja durante o período que foram interpolados pelo método *spline* conforme indicado por Zeileis and Grothendieck (2005).

Tabela 1: Resumo das séries de preços

acucar	etanol	soja	Data
Min. :32.97	Min. : 732.5	Min. : 39.99	Min. :2010-01-25
1st Qu.:48.25	1st Qu.:1105.1	1st Qu.: 49.13	1st Qu.:2011-10-20
Median :63.17	Median :1190.5	Median : 53.92	Median :2013-07-24
Mean :61.47	Mean :1238.0	Mean : 59.97	Mean :2013-07-23
3rd Qu.:73.06	3rd Qu.:1317.0	3rd Qu.: 71.58	3rd Qu.:2015-04-23
Max. :93.18	Max. :1924.5	Max. :100.92	Max. :2017-01-20

Para vizualização dos dados foi plotado na Figura 1 os gráficos do log da série de preços e do log da série de preços deflacionada. Optou-se pela apresentação na forma de logarítmo devido a diferença de escala entre o preço do etanol e dos preços da soja e açúcar. Na Figura 2 consta a volatilidade v_i do etanol, açúcar e soja medida pela seguinte fórmula:

$$v_i = \left(\Delta \log p_{i,t} \right)^2 .$$

Em que $p_{i,t}$ é o preço da *commodity* i e $i =$ etanol, açúcar ou soja. Percebe-se que a volatilidade do preço do açúcar é bem mais intensa e com maior amplitude se comparadas às volatilidades do preço do soja e do preço do etanol. Entretanto, conforme López Cabrera and Schulz (2016) é característico das séries de preços de *commodities* serem cointegradas e uma medida de volatilidade que leve em conta esta característica dos dados se torna mais apropriada. Para isso pode-se modelar a média da série de preços por meio e um modelo de correção de erros (VECM, sigla em inglês) e então filtrar a série de preços do co-movimento de suas médias condicionais.

```
## [1] "Mean"
```

```
##    etanol    acucar      soja
## 938.48581  46.35046  45.81921
```

```
## [1] "St.D."
```

```
##           etanol   acucar     soja
## etanol 126.37033      NaN 28.34079
## acucar       NaN 6.819198      NaN
## soja    28.34079      NaN 10.63687
```

```
## [1] "Corr."
```

```
##            etanol     acucar       soja
## etanol  1.0000000 -0.2186233  0.5975373
```

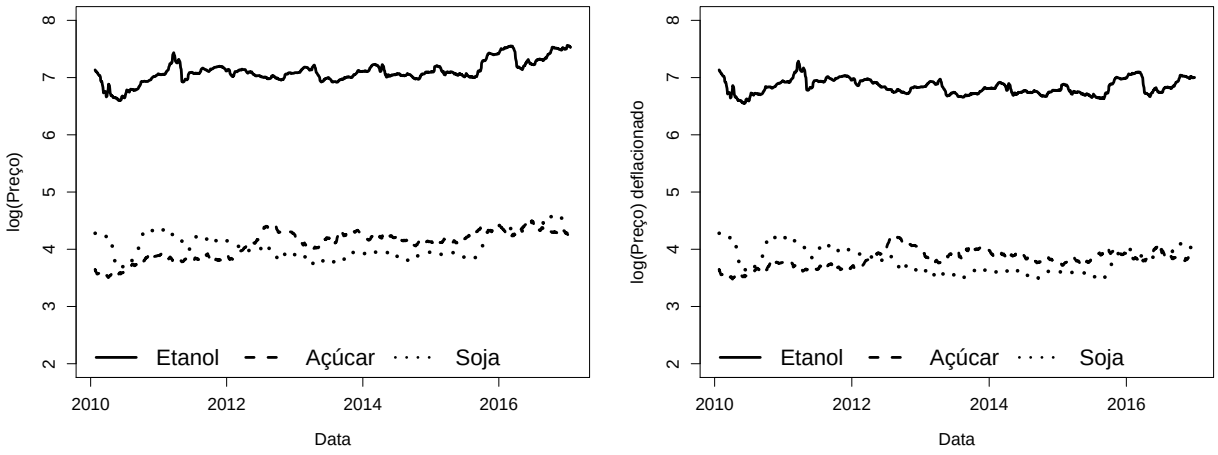

Figura 1: Logarítimo dos preços diários e preço diário deflacionado pelo Ìndice de Preço do Produtor (IPP) para o etanol, açúcar e soja

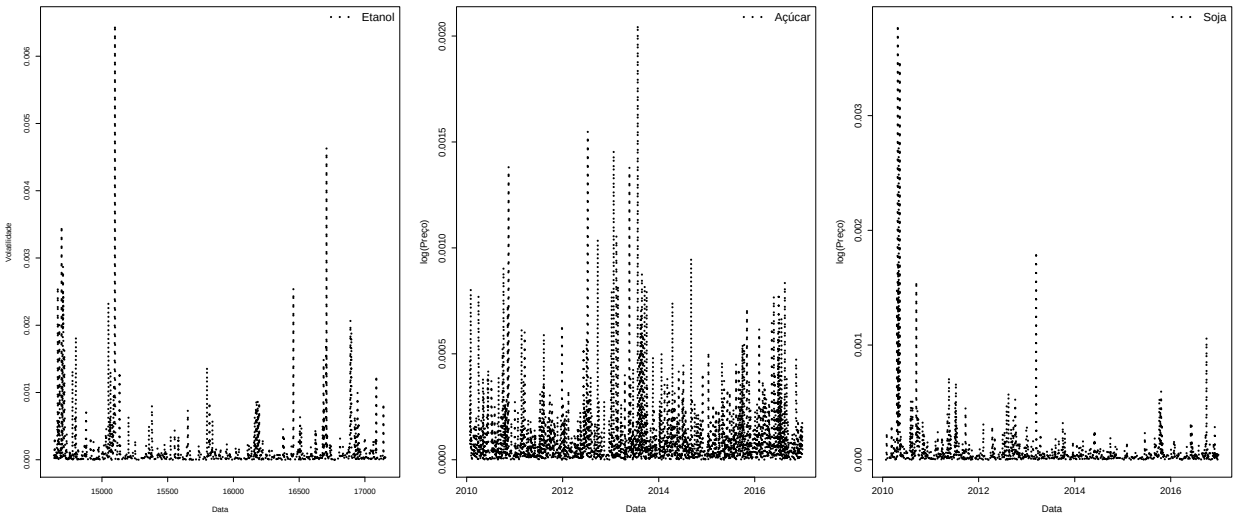

Figura 2: Volatilidade medida pela diferença do logarítimo do preço ao quadrado para a etanol, açúcar e soja

```
## acucar -0.2186233  1.0000000 -0.4075903
## soja    0.5975373 -0.4075903  1.0000000
```

```
## [1] "Skewness"
```

```
## [1] -0.2896277 -0.1595681 -1.0635649
```

```
## [1] "Kurtosis"
```

```
## [1] 12.333846  4.283914 12.858063
```

```
## [1] "Box Ljung (residuals)"
```

```
## [1] 0.000000e+00 5.107026e-15 0.000000e+00
```

```
## [1] "Box-Ljung (squared residuals)"
```

```
## [1] 0.000000e+00 2.233032e-07 0.000000e+00
```

```
## [1] "ARCH"
```

```
##  Chi-squared  Chi-squared  Chi-squared
## 0.0000000000 0.0006158753 0.0000000000
```

```
## [1] "Shapiro-Wilk"
```

```
## [1] 3.767565e-36 7.597055e-10 2.443580e-30
```

Tabela 2: Teste KPSS preço em nível

	etanol	acucar	soja	1 Pct	2.5 Pct	5 Pct	10 Pct
Time Trend:	1.57	3.80	5.17	0.22	0.18	0.15	0.12
No Trend:	1.88	10.65	9.45	0.74	0.57	0.46	0.35

Tabela 3: Teste ADF preço em nível

	etanol	acucar	soja	1 Pct	2.5 Pct	5 Pct	10 Pct
Time Trend:	-3.83	-1.67	-2.44	-3.96	-3.66	-3.41	-3.12
Constant:	-3.87	-1.90	-2.67	-3.43	-3.12	-2.86	-2.57
Neither:	-0.16	0.27	-0.39	-2.58	-2.23	-1.95	-1.62

Tabela 4: Defasagens do teste ADF

	Trend Model	Drift Model	None
etanol	2	2	2
acucar	1	1	1
soja	6	6	5

```
##
##  Phillips-Perron Unit Root Test
##
## data:  dados_cepea_deflacionado[, "etanol"]
## Dickey-Fuller Z(alpha) = -18.985, Truncation lag parameter = 8,
## p-value = 0.08703
## alternative hypothesis: stationary
```

```
##
##  Phillips-Perron Unit Root Test
##
## data:  dados_cepea_deflacionado[, "acucar"]
## Dickey-Fuller Z(alpha) = -6.7393, Truncation lag parameter = 8,
## p-value = 0.7338
## alternative hypothesis: stationary
```

```
##
##  Phillips-Perron Unit Root Test
##
## data:  dados_cepea_deflacionado[, "soja"]
## Dickey-Fuller Z(alpha) = -3.9061, Truncation lag parameter = 8,
## p-value = 0.8919
## alternative hypothesis: stationary
```

Tabela 5: Teste KPSS retorno

	etanol	acucar	soja	1 Pct	2.5 Pct	5 Pct	10 Pct
Time Trend:	0.05	0.06	0.11	0.22	0.18	0.15	0.12
No Trend:	0.15	0.14	0.72	0.74	0.57	0.46	0.35

Tabela 6: Teste ADF retorno

	etanol	acucar	soja	1 Pct	2.5 Pct	5 Pct	10 Pct
Time Trend:	-15.51	-25.43	-9.18	-3.96	-3.66	-3.41	-3.12
Constant:	-15.49	-25.42	-9.11	-3.43	-3.12	-2.86	-2.57
Neither:	-15.50	-25.42	-9.11	-2.58	-2.23	-1.95	-1.62

Tabela 7: Defasagens do teste ADF

	Trend Model	Drift Model	None
etanol	1	1	1
acucar	1	1	1
soja	4	4	4

```
##
##  Phillips-Perron Unit Root Test
##
## data:  ldif_cepea[-1, "etanol"]
## Dickey-Fuller Z(alpha) = -990.04, Truncation lag parameter = 8,
## p-value = 0.01
## alternative hypothesis: stationary
```

```
##
##  Phillips-Perron Unit Root Test
##
## data:  ldif_cepea[-1, "acucar"]
## Dickey-Fuller Z(alpha) = -1473.5, Truncation lag parameter = 8,
## p-value = 0.01
## alternative hypothesis: stationary
```

```
##
##  Phillips-Perron Unit Root Test
##
## data:  ldif_cepea[-1, "soja"]
## Dickey-Fuller Z(alpha) = -1685.5, Truncation lag parameter = 8,
## p-value = 0.01
## alternative hypothesis: stationary
```

```
## selected order: aic =  7
## selected order: bic =  4
## selected order: hq =  6
## Summary table:
##        p      AIC      BIC       HQ       M(p) p-value
##  [1,]  0 -11.5960 -11.5960 -11.5960     0.0000  0.0000
##  [2,]  1 -28.4651 -28.4365 -28.4545 28720.4234  0.0000
##  [3,]  2 -28.9585 -28.9014 -28.9374   855.9078  0.0000
##  [4,]  3 -29.0894 -29.0038 -29.0577   239.7097  0.0000
##  [5,]  4 -29.1391 -29.0250 -29.0969   101.8209  0.0000
##  [6,]  5 -29.1570 -29.0143 -29.1042    47.8572  0.0000
##  [7,]  6 -29.1725 -29.0013 -29.1091    43.8599  0.0000
##  [8,]  7 -29.1804 -28.9807 -29.1065    31.0196  0.0003
##  [9,]  8 -29.1738 -28.9456 -29.0894     6.4510  0.6941
## [10,]  9 -29.1677 -28.9109 -29.0727     7.2904  0.6069
## [11,] 10 -29.1624 -28.8771 -29.0568     8.6824  0.4671
## [12,] 11 -29.1553 -28.8415 -29.0392     5.6868  0.7708
## [13,] 12 -29.1497 -28.8073 -29.0230     8.0703  0.5271
## [14,] 13 -29.1438 -28.7729 -29.0066     7.6895  0.5657
```

```
##
## ######################
## # Johansen-Procedure #
## ######################
##
## Test type: trace statistic , with linear trend
##
## Eigenvalues (lambda):
## [1] 0.016725504 0.005288100 0.002397643
##
## Values of teststatistic and critical values of test:
##
##           test 10pct  5pct  1pct
## r <= 2 |  4.12  6.50  8.18 11.65
## r <= 1 | 13.22 15.66 17.95 23.52
## r = 0  | 42.16 28.71 31.52 37.22
##
## Eigenvectors, normalised to first column:
## (These are the cointegration relations)
##
##             etanol.l3  acucar.l3    soja.l3
## etanol.l3  1.00000000   1.000000  1.0000000
## acucar.l3 -0.02988903 -19.561243 -0.8718529
## soja.l3   -0.31575726  -3.996291 -4.4371453
##
## Weights W:
## (This is the loading matrix)
```

```
##
##             etanol.l3     acucar.l3      soja.l3
## etanol.d -0.009108278 -1.126194e-04 2.354312e-05
## acucar.d -0.005376216  1.926758e-04 2.252981e-04
## soja.d    0.001030792 -5.708165e-05 3.441345e-04

##
## ######################################################
## # Johansen-Procedure Unit Root / Cointegration Test #
## ######################################################
##
## The value of the test statistic is: 4.1193 13.2178 42.1614

## [1] "VECM ols"

## alpha:
##        etanol   acucar    soja
## [1,] -0.00968 -0.00529 0.00104
## standard error
##         [,1]    [,2]    [,3]
## [1,] 0.00195 0.00215 0.00151
## AR coefficient matrix
## AR( 1 )-matrix
##         etanol  acucar     soja
## etanol  0.3730 -0.0543 -0.00696
## acucar -0.0145  0.1943  0.02106
## soja    0.0171  0.0154  0.21612
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0241 0.0221 0.0307
## [2,] 0.0265 0.0243 0.0338
## [3,] 0.0186 0.0171 0.0237
## AR( 2 )-matrix
##        etanol  acucar    soja
## etanol 0.2617 -0.0101 -0.0283
## acucar 0.0165  0.0184  0.0104
## soja   0.0602 -0.0274  0.1748
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0250 0.0225 0.0309
## [2,] 0.0275 0.0248 0.0340
## [3,] 0.0193 0.0174 0.0239
## AR( 3 )-matrix
##          etanol    acucar    soja
## etanol  0.03512 -0.042739  0.0296
## acucar -0.00229  0.010066 -0.0165
## soja   -0.01668 -0.000225  0.2327
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0243 0.0221 0.0306
## [2,] 0.0268 0.0244 0.0337
## [3,] 0.0188 0.0171 0.0237
## -----
## Residuals cov-mtx:
##              etanol       acucar         soja
```

```
## etanol 6.714620e-05 3.961111e-06 4.825925e-06
## acucar 3.961111e-06 8.148757e-05 7.242273e-06
## soja   4.825925e-06 7.242273e-06 4.014542e-05
##
## det(sse) =  2.138862e-13
## AIC =  -29.13843
## BIC =  -29.04332
```

```
## [1] "Refinamento VECM ols"
```

```
## Equation:  1  npar =  6
## Equation:  2  npar =  2
## Equation:  3  npar =  5
## alpha:
##          [,1]     [,2] [,3]
## [1,] -0.00964 -0.00537    0
## standard error
##         [,1]    [,2] [,3]
## [1,] 0.00195 0.00212    1
## AR coefficient matrix
## AR( 1 )-matrix
##       [,1]    [,2] [,3]
## [1,] 0.373 -0.0574 0.00
## [2,] 0.000  0.2000 0.00
## [3,] 0.000  0.0000 0.22
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0239 0.0215 1.0000
## [2,] 1.0000 0.0237 1.0000
## [3,] 1.0000 1.0000 0.0234
## AR( 2 )-matrix
##        [,1]    [,2]  [,3]
## [1,] 0.2584  0.0000 0.000
## [2,] 0.0000  0.0000 0.000
## [3,] 0.0613 -0.0259 0.174
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0248 1.0000 1.0000
## [2,] 1.0000 1.0000 1.0000
## [3,] 0.0154 0.0167 0.0239
## AR( 3 )-matrix
##        [,1]    [,2] [,3]
## [1,] 0.0368 -0.0432 0.00
## [2,] 0.0000  0.0000 0.00
## [3,] 0.0000  0.0000 0.23
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0241 0.0216 1.0000
## [2,] 1.0000 1.0000 1.0000
## [3,] 1.0000 1.0000 0.0234
## -----
## Residuals cov-mtx:
##              [,1]         [,2]         [,3]
## [1,] 6.721523e-05 3.909699e-06 4.830615e-06
## [2,] 3.909699e-06 8.158966e-05 7.222317e-06
```

```
## [3,] 4.830615e-06 7.222317e-06 4.020320e-05
##
## det(sse) =  2.147254e-13
## AIC =  -29.15429
## BIC =  -29.11308
```

```
## [1] "VECM MLL"
```

```
## Order p:  4  Co-integrating rank:  1
## Number of parameters:  32
## initial estimates:  -0.009374727 -0.003209131 0.0004045168 -0.3 -0.316 0.3715428 -0.05441418 -0.0091
## Par. Lower-bounds:  -0.01210885 -0.006225814 -0.001710967 -0.3361787 -0.3521787 0.3354285 -0.0875187
## Par. Upper-bounds:  -0.0066406 -0.0001924473 0.00252 -0.2638213 -0.2798213 0.407657 -0.02130963 0.030
## Final   Estimates:  -0.0066406 -0.0004365751 -0.0004796343 -0.3361787 -0.3521787 0.3704735 -0.0295038
##
## Coefficient(s):
##         Estimate  Std. Error  t value Pr(>|t|)
##  [1,] -0.0066406          NA       NA       NA
##  [2,] -0.0004366   0.0001828   -2.388 0.016946 *
##  [3,] -0.0004796   0.0001273   -3.768 0.000165 ***
##  [4,] -0.3361787   0.3382068   -0.994 0.320221
##  [5,] -0.3521787   0.3412452   -1.032 0.302053
##  [6,]  0.3704735   0.0855833    4.329 1.50e-05 ***
##  [7,] -0.0295039   0.0783249   -0.377 0.706407
##  [8,] -0.0552104   0.1090822   -0.506 0.612762
##  [9,]  0.2358613   0.0888778    2.654 0.007960 **
## [10,]  0.0121888   0.0797436    0.153 0.878517
## [11,] -0.0540116   0.1095726   -0.493 0.622062
## [12,]  0.0296017   0.0858413    0.345 0.730213
## [13,] -0.0222041   0.0784180   -0.283 0.777061
## [14,] -0.0190241   0.1086289   -0.175 0.860978
## [15,] -0.0145144   0.0271424   -0.535 0.592821
## [16,]  0.2030534   0.0248698    8.165 2.22e-16 ***
## [17,]  0.0054193   0.0345212    0.157 0.875256
## [18,]  0.0075839   0.0281935    0.269 0.787934
## [19,]  0.0214437   0.0253255    0.847 0.397149
## [20,] -0.0019785   0.0341446   -0.058 0.953792
## [21,] -0.0148118   0.0272380   -0.544 0.586586
## [22,]  0.0138260   0.0248891    0.556 0.578549
## [23,] -0.0304167   0.0344829   -0.882 0.377733
## [24,]  0.0107346   0.0194915    0.551 0.581819
## [25,]  0.0157456   0.0178546    0.882 0.377844
## [26,]  0.2160566   0.0248678    8.688  < 2e-16 ***
## [27,]  0.0506994   0.0202497    2.504 0.012290 *
## [28,] -0.0315468   0.0181912   -1.734 0.082885 .
## [29,]  0.1685565   0.0249822    6.747 1.51e-11 ***
## [30,] -0.0077059   0.0195501   -0.394 0.693461
## [31,] -0.0019107   0.0178543   -0.107 0.914774
## [32,]  0.2271728   0.0247883    9.165  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## alpha:
##           [,1]
## [1,] -0.006641
## [2,] -0.000437
```

```
## [3,] -0.000480
## standard error
##          [,1]
## [1,]      NaN
## [2,] 0.000183
## [3,] 0.000127
## beta:
##        [,1]
## [1,]  1.000
## [2,] -0.336
## [3,] -0.352
## standard error
##       [,1]
## [1,] 1.000
## [2,] 0.338
## [3,] 0.341
## AR coefficient matrix
## AR( 1 )-matrix
##         [,1]    [,2]     [,3]
## [1,]  0.3705 -0.0295 -0.05521
## [2,] -0.0145  0.2031  0.00542
## [3,]  0.0107  0.0157  0.21606
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0856 0.0783 0.1091
## [2,] 0.0271 0.0249 0.0345
## [3,] 0.0195 0.0179 0.0249
## AR( 2 )-matrix
##         [,1]    [,2]     [,3]
## [1,] 0.23586  0.0122 -0.05401
## [2,] 0.00758  0.0214 -0.00198
## [3,] 0.05070 -0.0315  0.16856
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0889 0.0797 0.1096
## [2,] 0.0282 0.0253 0.0341
## [3,] 0.0202 0.0182 0.0250
## AR( 3 )-matrix
##          [,1]     [,2]    [,3]
## [1,]  0.02960 -0.02220 -0.0190
## [2,] -0.01481  0.01383 -0.0304
## [3,] -0.00771 -0.00191  0.2272
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0858 0.0784 0.1086
## [2,] 0.0272 0.0249 0.0345
## [3,] 0.0196 0.0179 0.0248
## -----
## Residuals cov-mtx:
##              etanol       acucar         soja
## etanol 8.464302e-04 5.735088e-05 5.955313e-05
## acucar 5.735088e-05 8.526871e-05 1.091269e-05
## soja   5.955313e-05 1.091269e-05 4.396170e-05
##
```

```
## det(sse) =  2.699629e-12
## AIC =  -26.60068
## BIC =  -26.49923
```

```
## [1] "Refinamento VECM MLL"
```

```
## Order p:  4  Co-integrating rank:  1
## Number of parameters:  13
## initial estimates:  -0.0066406 -0.0004365751 -0.0004796343 -0.3361787 -0.3521787 0.3704735 0.2358613
## Par. Lower-bounds:  NaN -0.0007108197 -0.0006705721 -0.3723575 -0.3883575 0.2420985 0.1025446 0.1657
## Par. Upper-bounds:  NaN -0.0001623304 -0.0002886965 -0.3 -0.316 0.4988485 0.369178 0.240358 0.253358
## Final   Estimates:  -0.0066406 -0.0001623304 -0.0002886965 -0.3723575 -0.3883575 0.2420985 0.369178
##
## Coefficient(s):
##         Estimate  Std. Error  t value Pr(>|t|)
##  [1,] -0.0066406          NA       NA       NA
##  [2,] -0.0001623   0.0001826   -0.889  0.37413
##  [3,] -0.0002887   0.0001290   -2.238  0.02524 *
##  [4,] -0.3723575   0.3174371   -1.173  0.24079
##  [5,] -0.3883575   0.3202451   -1.213  0.22525
##  [6,]  0.2420985   0.0751525    3.221  0.00128 **
##  [7,]  0.3691780   0.0768190    4.806 1.54e-06 ***
##  [8,]  0.2403580   0.0235197   10.219  < 2e-16 ***
##  [9,]  0.2533582   0.0233280   10.861  < 2e-16 ***
## [10,]  0.0810739   0.0156425    5.183 2.18e-07 ***
## [11,] -0.0042601   0.0165967   -0.257  0.79742
## [12,]  0.2060298   0.0237682    8.668  < 2e-16 ***
## [13,]  0.2643553   0.0233053   11.343  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## alpha:
##           [,1]
## [1,] -0.006641
## [2,] -0.000162
## [3,] -0.000289
## standard error
##          [,1]
## [1,]      NaN
## [2,] 0.000183
## [3,] 0.000129
## beta:
##        [,1]
## [1,]  1.000
## [2,] -0.372
## [3,] -0.388
## standard error
##       [,1]
## [1,] 1.000
## [2,] 0.317
## [3,] 0.320
## AR coefficient matrix
## AR( 1 )-matrix
##       [,1] [,2]  [,3]
## [1,] 0.242 0.00 0.000
## [2,] 0.000 0.24 0.000
```

```
## [3,] 0.000 0.00 0.253
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0752 1.0000 1.0000
## [2,] 1.0000 0.0235 1.0000
## [3,] 1.0000 1.0000 0.0233
## AR( 2 )-matrix
##        [,1]     [,2]  [,3]
## [1,] 0.3692  0.00000 0.000
## [2,] 0.0000  0.00000 0.000
## [3,] 0.0811 -0.00426 0.206
## standard error
##        [,1]   [,2]   [,3]
## [1,] 0.0768 1.0000 1.0000
## [2,] 1.0000 1.0000 1.0000
## [3,] 0.0156 0.0166 0.0238
## AR( 3 )-matrix
##      [,1] [,2]  [,3]
## [1,]    0    0 0.000
## [2,]    0    0 0.000
## [3,]    0    0 0.264
## standard error
##      [,1] [,2]   [,3]
## [1,]    1    1 1.0000
## [2,]    1    1 1.0000
## [3,]    1    1 0.0233
## -----
## Residuals cov-mtx:
##              etanol       acucar         soja
## etanol 7.498651e-04 2.248021e-05 3.363317e-05
## acucar 2.248021e-05 8.234223e-05 7.809303e-06
## soja   3.363317e-05 7.809303e-06 4.177998e-05
##
## det(sse) =  2.431548e-12
## AIC =  -26.72737
## BIC =  -26.68616
```

Referências

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