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LA TEORIA DE LA CREDIBILIDAD

Y SU APLICACION A LOS SEGUROS COLECTIVOS

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APENDICE DE LAS FUNCIONES UTILIZADAS EN EL CAPITULO VI

INDICE DEL CAPITULO

1.- MODELO DE BÜHLMANN

La función **BUHLMANN** recoge la información de las funciones READ y READCONTRACT para hacer los cálculos de la función BUHL.

```
      ∇BUHLMANN[⎕]∇
[0]   BUHLMANN;XX;X;⎕IO
[1]   ⍝ THE COMPLETE MODEL OF H. BUHLMANN
[2]    ⎕IO←1
[3]    X←READ 0
[4]    X←X[1]READCONTRACT X[2]
[5]    BUHL X
```

La función **READ** pide el número de pólizas y de periodos considerados.

```
      ∇READ[⎕]∇
[0]   X←READ BIN;J;T;K;TE
[1]    ' '
[2]    ⎕←TE←'HOW MANY CONTRACTS DO YOU CONSIDER: '
[3]    K←⍎(⍴TE)↓⎕
[4]    →SMALL×⍳K<2
[5]    ' '
[6]    ⎕←TE←'HOW MANY PERIODS DO YOU CONSIDER: '
[7]    T←⍎(⍴TE)↓⎕
[8]    →SMALL×⍳T<2+BIN
[9]    →0,X←T,K
[10]  SMALL:' '
[11]   'YOUR DIMENSIONS ARE TOO SMALL TO COMPUTE PREMIUMS WITH THE HELP OF'
[12]   'CREDIBILITY-THEORY !!!'
[13]   →
```

La función **READCONTRACT** pide las t observaciones de cada póliza.

```
      ∇READCONTRACT[⎕]∇
[0]   X←T READCONTRACT K;J;HELP;TE
[1]    X←(T,K)⍴0
[2]    J←1
[3]   LAB1:' '
[4]    'GIVE IN THE ',(⍕T),' NUMBERS OF CONTRACT ',(⍕J),': '
[5]    →ERROR×⍳T≠⍴,HELP←⍎⎕
[6]    X[;J]←HELP
[7]    →LAB1×⍳K≥J←J+1
[8]    →0
[9]   ERROR:' '
[10]   'YOU HAVE GIVEN IN  ',(⍕⍴,HELP),' NUMBERS INSTEAD OF ',(⍕T),'.'
[11]   →LAB1,⍴⎕←'TRY AGAIN !'
```

La función **BUHL** calcula los estimadores individuales, el estimador colectivo, el factor de credibilidad, los estimadores de credibilidad para cada póliza y los estimadores de los parámetros estructurales S^2 y a.

```
     ∇BUHL[⎕]∇
[0]  BUHL X;T;K;MC;MI;S2;A;Z;MA;⎕IO
[1]   ⎕IO←1
[2]   MC←(÷K←1↓⍴X)×+/MI←(÷T←1↑⍴X)×+⌿X
[3]   S2←(÷K×T-1)×+/+/(X-(T,K)⍴MI)*2
[4]   A←0⌈((÷K-1)×+/(MI-MC)*2)-S2÷T
[5]   MA←(Z×MI)+MC×1-Z←A×T÷S2+A×T
[6]   RESULTSBUHL
```

La función **RESULTBUHL** proporciona el formato de salida de los resultados de la función BUHL.

```
     ∇RESULTSBUHL[⎕]∇
[0]  RESULTSBUHL;TITLE;K;J;MAT
[1]   K←⍴MI
[2]   MAT←2 2⍴' '
[3]   MAT
[4]   TITLE←'BUHLMANN METHOD'
[5]   TITLE
[6]   (⍴TITLE)⍴'*'
[7]   MAT
[8]   'THE INDIVIDUAL ESTIMATORS:'
[9]   '==========================='
[10]  J←1
[11] LAB1:'    CONTRACT ',(⍕J),': ',⍕MI[J]
[12]  →LAB1×⍳K≥J←J+1
[13]  ' '
[14]  'THE COLLECTIVE ESTIMATOR: ',⍕MC
[15]  '==========================='
[16]  ' '
[17]  'THE CREDIBILITY ADJUSTED ESTIMATORS:'
[18]  '====================================='
[19]  J←1
[20] LAB2:'    CONTRACT ',(⍕J),': ',⍕MA[J]
[21]  →LAB2×⍳K≥J←J+1
[22]  ' '
[23]  'OBTAINED WITH Z = ',⍕Z
[24]  '              S2= ',⍕S2
[25]  '               A = ',⍕A
[26]  ' '
```

2.- MODELO DE BÜHLMANN-STRAUB

La función **BUHLMANNSTRA** recoge la información de las funciones READ, READCONTRACT y READWEIGHT para hacer los cálculos de la función BUST.

```
      ∇BUHLMANNSTRA[⎕]∇
[0]   BUHLMANNSTRA;X;W;⎕IO;XX
[1]   ⍝ THE BUHLMANN-STRAUB METHOD
[2]    ⎕IO←1
[3]    XX←READ 0
[4]    X←XX[1]READCONTRACT XX[2]
[5]    W←XX[1]READWEIGHT XX[2]
[6]    W BUST X
```

La función **READWEIGHT** pide los t pesos para cada póliza.

```
      ∇READWEIGHT[⎕]∇
[0]   W←T READWEIGHT K;J;HELP;TE
[1]    W←(T,K)⍴0
[2]    J←1
[3]   LAB1:→0
[4]    'GIVE IN THE ',(⍕T),' WEIGHTS OF CONTRACT ',(⍕J),': '
[5]    →ERROR×⍳T≠⍴HELP←⍞
[6]    W[;J]←HELP
[7]    →LAB1×⍳K⋄J←J+1
[8]    →0
[9]   ERROR:' '
[10]   'YOU HAVE GIVEN IN ',(⍕⍴HELP),' NUMBERS INSTEAD OF ',(⍕T),'.'
[11]   →LAB1,⍴⎕←'TRY AGAIN !!'
```

La función **BUST** calcula los estimadores individuales, el estimador colectivo, los factores de credibilidad y los estimadores de credibilidad para cada póliza, y los estimadores de los parámetros estructurales S^2 y a.

```
      ∇BUST[⎕]∇
[0]   W BUST X;K;T;WC;WI;MI;MC;XC;S2;A;Z;MA;HELP;⎕IO
[1]    ⎕IO←1
[2]    K←1↓⍴X
[3]    T←1↑⍴X
[4]    XC←(÷WC←+/WI)×+/WI×MI←(÷WI←+/W)×+/W×X
[5]    S2←(÷K×T-1)×+/+/W×(X-(⍴X)⍴MI)*2
[6]    A←0⌈(WC÷(WC*2)-+/WI*2)×(+/WI×(MI-XC)*2)-S2×K-1
[7]    Z←A×WI÷S2+A×WI
[8]    →ERROR×⍳0=HELP←+/Z
[9]    MC←(÷HELP)×+/Z×MI
[10]   MA←(Z×MI)+MC×1-Z
[11]   RESULTSBUST
[12]   →0
[13]  ERROR:'ALL CREDIBILITY-FACTORS ARE EQUAL TO 0.'
```

La función **RESULSTBUST** proporciona el formato de salida de los resultados de la función BUST.

```
      ∇RESULTSBUST[⎕]∇
[0]   RESULTSBUST;TITLE;MAT;J;K
[1]    K←⍴MI
[2]    MAT←2 2⍴' '
[3]    MAT
[4]    TITLE←'BUHLMANN-STAUB MODEL'
[5]    TITLE
[6]    (⍴TITLE)⍴'*'
[7]    MAT
[8]    'THE INDIVIDUAL ESTIMATORS:'
[9]    '=========================='
[10]   J←1
[11]  LAB1:'    CONTRACT ',(⍕J),': ',⍕MI[J]
[12]   →LAB1×⍳K≥J←J+1
[13]   ' '
[14]   'THE COLLECTIVE ESTIMATOR: ',⍕MC
[15]   '=========================='
[16]   ' '
[17]   'THE CREDIBILITY ADJUSTED ESTIMATORS:'
[18]   '==================================='
[19]   J←1
[20]  LAB2:'    CONTRACT ',(⍕J),': ',⍕MA[J]
[21]   →LAB2×⍳K≥J←J+1
[22]   ' '
[23]   'OBTAINED WITH Z'
[24]   J←1
[25]  LAB3:'  FOR CONTRACT ',(⍕J),' = ',⍕Z[J]
[26]   →LAB3×⍳K≥J←J+1
[27]   '                S2= ',⍕S2
[28]   '                A = ',⍕A
```

3.- MODELO DE REGRESION DE HACHEMEISTER

La función **HACHEMEISTER** recoge la información de las funciones READ, READCONTRACT y FORMV para hacer los cálculos de la función HACH.

```
      ∇HACHEMEISTER[⎕]∇
[0]   HACHEMEISTER;V;X;XX;⎕IO
[1]   ⍝ THE HACHEMEISTER REGRESSION MODEL
[2]    XX←READ ⎕IO←1
[3]    X←XX[1]READCONTRACT XX[2]
[4]    V←XX[1]FORMV XX[2]
[5]    V HACH X
```

La función **FORMV** pide los t pesos de cada póliza y calcula las matrices $v_{pj}^{-1} = \text{diag}(w_{j1}, w_{j2}, \ldots, w_{jt})$.

```
     ∇FORMV[⎕]∇
[0]  V←T FORMV K;J;A;TE
[1]   V←(K,2×T)⍴0
[2]   ⍳0
[3]   'CAUTION: WEIGHT=1÷PRECISION !!'
[4]   '--------'
[5]   J←1
[6]  LAB1:' '
[7]   'GIVE IN THE ',(⍕T),' WEIGHTS OF CONTRACT ',(⍕J),': '
[8]   →ERROR×⍳T≠⍴A←,⍎⍞
[9]   A[(A=0)/⍳⍴A]←0.001
[10]  V[J;;1]←A
[11]  V[J;;]←(⌽⍳T)⌽V[J;;]
[12]  →LAB1×⍳K≥J←J+1
[13]  →0
[14] ERROR:⍳0
[15]  'YOU HAVE TO GIVE IN ',(⍕T),' NUMBERS.'
[16]  →LAB1,⍴⎕←'TRY AGAIN !!!'
```

La función **HACH** recoge la información de la función FORMV y calcula los estimadores individuales, el estimador colectivo, las matrices de credibilidad y los estimadores de credibilidad para cada póliza, y los estimadores de los parámetros estructurales S^2 y a.

```
     ∇HACH[⎕]∇
[0]  V HACH X;A;BA;BC;BCOLD;BI;ALPHA;HELP;J;K;KM1;S2;S2AL;T;K;Y;YT;Z;N;O;IT
[1]   ⎕IO←1
[2]   KM1←¯1+K←1↓⍴X
[3]   N←1↓⍴Y←FORMY T←1↑⍴X
[4]   BI←(K,N,1)⍴0
[5]   Z←1+ALPHA←(K,N,N)⍴0
[6]   J←1+S2←0
[7]  LAB1:ALPHA[J;;]←⌹(YT←⍉Y)+.×V[J;;]+.×Y
[8]   HELP←X[;J]-Y+.×BI[J;;]←ALPHA[J;;]+.×YT+.×V[J;;]+.×X[;J]
[9]   S2←S2+(⍉HELP)+.×V[J;;]+.×HELP
[10]  →LAB1×⍳K≥J←J+1
[11]  S2AL←ALPHA×S2←S2÷K×T-N
[12]  BCOLD←(N,1)⍴+/BI
[13]  IT←0
[14] BEGIN:J←1
[15]  IT←IT+1
[16]  A←(N,N)⍴0
[17] BEG1:A←A+Z[J;;]+.×HELP+.×⍉HELP←BI[J;;]-BCOLD
[18]  →BEG1×⍳K≥J←J+1
[19]  A←(÷2)×A+⍉A←A÷KM1
[20]  BC←(⍴BCOLD)⍴0
[21]  J←1
[22] BEG2:Z[J;;]←A+.×⌹A+S2AL[J;;]
[23]  BC←BC+Z[J;;]+.×BI[J;;]
[24]  →BEG2×⍳K≥J←J+1
[25]  BC←(⌹+/Z)+.×BC
[26]  →⍷TOP×⍳(0.00001>|/⌈/|(BCOLD-BC)÷BCOLD)∨IT≥50
```

```
[27]  BCOLD←BC
[28]  →BEGIN
[29] STOP:BA←(K,N,1)⍴0
[30]  J←1
[31]  O←(N,N)⍴1,(N⍴0)
[32] ST1:BA[J;;]←(Z[J;;]+.×BI[J;;])+(O-Z[J;;])+.×BC
[33]  →ST1×⍳K≥J←J+1
[34]  RESULTSHACH
```

La función **FORMY** genera las matrices $Y_j = \begin{bmatrix} 1 & t \\ 1 & t-1 \\ \vdots & \vdots \\ 1 & 1 \end{bmatrix}$

```
     ∇FORMY[⎕]∇
[0]  Y←FORMY T
[1]   Y←(⍉⍳T)∘.*0 1
```

La función **RESULTSHACH** proporciona el formato de salida de los resultados de la función HACH.

```
     ∇RESULTSHACH[⎕]∇
[0]  RESULTSHACH;K;J;TITLE;MAT
[1]   K←1↑⍴BI
[2]   MAT←2 2⍴' '
[3]   TITLE←'HACHEMEISTER REGRESSION METHOD'
[4]   MAT
[5]   TITLE
[6]   (⍴TITLE)⍴'*'
[7]   MAT
[8]   'SOLUTION OBTAINED AFTER ',(⍕IT),' ITERATIONS: '
[9]   MAT
[10]  'THE INDIVIDUAL ESTIMATORS:'
[11]  '=========================='
[12]  J←1
[13] LAB1:' '
[14]  'CONTRACT ',(⍕J),':'
[15]  '      INTERCEPT: ',⍕BI[J;1;]
[16]  '      SLOPE:     ',⍕BI[J;2;]
[17]  →LAB1×⍳K≥J←J+1
[18]  MAT
[19]  'THE COLLECTIVE ESTIMATORS:'
[20]  '=========================='
[21]  ' '
[22]  '      INTERCEPT: ',⍕BC[1;]
[23]  '      SLOPE:     ',⍕BC[2;]
[24]  MAT
[25]  'THE CREDIBILITY ADJUSTED ESTIMATORS:'
[26]  '===================================='
[27]  J←1
[28] LAB2:' '
[29]  'CONTRACT ',(⍕J),':'
[30]  '      INTERCEPT: ',⍕BA[J;1;]
[31]  '      SLOPE:     ',⍕BA[J;2;]
[32]  →LAB2×⍳K≥J←J+1
[33]  MAT
[34]  'OBTAINED WITH S2= ',⍕S2
[35]  '                A = '
[36]  ((N,16)⍴' '),⍕A
```

```
[37]  'AND WITH CREDIBILITY FACTORS Z EQUAL TO'
[38]  J←1
[39] LAB3:'CONTRACT ',(⍕J),':'
[40]  ((N,16)⍴' '),⍕Z[J;;]
[41]  →LAB3×⍳K≥J←J+1
```

4.- MODELO DE SEMILINEAL DE De VYLDER

La función **SEMILINEAR** recoge la información de las funciones READ y READCONTRACT para hacer los cálculos de la función SELI.

```
      ∇SEMILINEAR[⎕]∇
[0]  SEMILINEAR;X;⎕IO
[1]  ⍝ THE DE VYLDER SEMI-LINEAR MODEL
[2]   ⎕IO←1
[3]   X←READ 0
[4]   X←X[1]READCONTRACT X[2]
[5]   SELI X
```

La función **SELI** nos pide la definición de las funciones F(X) y G(X) que queremos utilizar, y calcula los estimadores individuales, el factor de credibilidad, los estimadores de credibilidad para cada póliza, y los estimadores de los parámetros estructurales.

```
      ∇SELI[⎕]∇
[0]  SELI X;AFF;BFF;BFG;K;KM1;T;Y;Z;YS;ZS;MF;MG;HELP;BA;⎕IO;AFG
[1]   ⎕IO←1
[2]   KM1←÷¯1+K←1↓⍴X
[3]   ' '
[4]   'GIVE IN THE DEFINITION OF THE FUNCTIONS F AND G IN A.P.L.'
[5]   'THE VARIABLE HAS TO BE NAMED X.'
[6]   ⎕←HELP←'F(X)←'
[7]   Y←⍎(⍴HELP)↓⎕
[8]   ⎕←HELP←'G(X)←'
[9]   Z←⍎(⍴HELP)↓⎕
[10]  MF←(÷K)×+/YS←(÷T←1↑⍴X)×+/Y
[11]  MG←(÷K)×+/ZS←(÷T)×+/Z
[12]  AFF←(÷K×T-1)×+/+/(Y-(⍴Y)⍴YS)*2
[13]  AFG←(÷K×T-1)×+/+/(Y-(⍴Y)⍴YS)×Z-(⍴Z)⍴ZS
[14]  BFG←(KM1×+/(YS-MF)×ZS-MG)-AFG÷T
[15]  BFF←(KM1×+/(YS-MF)*2)-AFF÷T
[16]  Z←(T×BFG)÷AFF+T×BFF
[17]  BA←MG+Z×YS-MF
[18]  RESULTSSELI
```

La función **RESULTSSELI** proporciona el formato de salida de los resultados de la función SELI.

```
     ∇RESULTSSELI[⎕]∇
[0]  RESULTSSELI;K;MAT;TITLE;J
[1]   K←⍴BA
[2]   MAT←2 2⍴' '
[3]   MAT
[4]   TITLE←'THE DE VYLDER SEMI-LINEAR MODEL'
[5]   TITLE
[6]   (⍴TITLE)⍴'*'
[7]   MAT
[8]   'THE CREDIBILITY ADJUSTED ESTIMATORS:'
[9]   '====================================='
[10]  J←1
[11] LAB1:'    CONTRACT ',(⍕J),': ',⍕BA[J]
[12]  →LAB1×⍳K≥J←J+1
[13]  ' '
[14]  'OBTAINED WITH Z  = ',⍕Z
[15]  'COLLECTIVE ESTIMATORS:  MF = ',⍕MF
[16]  '                        MG = ',⍕MG
[17]  'EXPECTATION OF VARIANCE:AFF= ',⍕AFF
[18]  '                        AFG= ',⍕AFG
[19]  'VARIANCE OF EXPECTATION:BFF= ',⍕BFF
[20]  '                        BFG= ',⍕BFG
[21]  ' '
```

5.- MODELO JERARQUICO DE JEWELL

La función **JEWELL** pide el número de subcarteras que queremos considerar, y según el número elegido invoca la función VALOR2, VALOR3, VALOR4 o VALOR5.

```
     ∇JEWELL[⎕]∇
[0]  JEWELL;P;⎕IO
[1]  ⍝ MODELO JERARQUICO DE JEWELL
[2]   ⎕IO←1
[3]   'INTRODUCE EL NUMERO DE SUBCARTERAS (ENTRE 2 Y 5):'
[4]   P←⎕
[5]   →(P=2)⍴VAL2
[6]   →(P=3)⍴VAL3
[7]   →(P=4)⍴VAL4
[8]   →(P=5)⍴VAL5
[9]   →(P≥5)⍴0
[10] VAL2:' '
[11]  VALOR2
[12]  →0
```

```
[13] VAL3:' '
[14]  VALOR3
[15]  →0
[16] VAL4:' '
[17]  VALOR4
[18]  →0
[19] VAL5:' '
[20]  VALOR5
```

Las funciones **VALOR2**, **VALOR3**, **VALOR4** y **VALOR5** recogen, para el caso de considerar dos, tres, cuatro o cinco subcarteras respectivamente, la información de las funciones LEER, LEERPOL y LEERPES para cada subcartera, y de la función SCUAD, para poder hacer los cálculos de la función CALCULO.

VALOR2:

```
      ∇VALOR2[⎕]∇
[0]  VALOR2;X1;X2;XX1;XX2;W1;W2;XT;WT;P;⎕IO;S2;XW;VK
[1]   P←2
[2]   ⎕IO←1
[3]   ' '
[4]   'SUBCARTERA 1'
[5]   '========== '
[6]   ' '
[7]   XX1←LEER 0
[8]   X1←XX1[1]LEERPOL XX1[2]
[9]   '============================================================='
[10]  '============================================================='
[11]  W1←XX1[1]LEERPES XX1[2]
[12]  ' '
[13]  'SUBCARTERA 2'
[14]  '========== '
[15]  ' '
[16]  XX2←LEER 0
[17]  X2←XX2[1]LEERPOL XX2[2]
[18]  '============================================================='
[19]  '============================================================='
[20]  W2←XX2[1]LEERPES XX2[2]
[21]  XT←X1,X2
[22]  WT←W1,W2
[23]  S2←XT SCUAD WT
[24]  XW←(2,(⍴XT))⍴0
[25]  XW[1;;]←XT
[26]  XW[2;;]←WT
[27]  VK←S2,XX1[2],XX2[2]
[28]  VK CALCULO XW
```

VALOR3:

```
      ∇VALOR3[⎕]∇
[0]  VALOR3;X1;X2;X3;W1;W2;W3;XX1;XX2;XX3;P;⎕IO;XT;WT;S2;XW;VK
[1]   P←3
[2]   ⎕IO←1
[3]   ' '
[4]   'SUBCARTERA 1'
[5]   '==========='
```

```
[6]   ' '
[7]   XX1←LEER 0
[8]   X1←XX1[1]LEERPOL XX1[2]
[9]   '============================================================ '
[10]  '============================================================ '
[11]  W1←XX1[1]LEERPES XX1[2]
[12]  ' '
[13]  'SUBCARTERA 2'
[14]  '==========='
[15]  ' '
[16]  XX2←LEER 0
[17]  X2←XX2[1]LEERPOL XX2[2]
[18]  '============================================================ '
[19]  '============================================================ '
[20]  W2←XX2[1]LEERPES XX2[2]
[21]  ' '
[22]  'SUBCARTERA 3'
[23]  '==========='
[24]  '  '
[25]  XX3←LEER 0
[26]  X3←XX3[1]LEERPOL XX3[2]
[27]  '============================================================ '
[28]  '============================================================ '
[29]  W3←XX3[1]LEERPES XX3[2]
[30]  XT←X1,X2,X3
[31]  WT←W1,W2,W3
[32]  S2←XT SCUAD WT
[33]  XW←(2,(⍴XT))⍴0
[34]  XW[1;;]←XT
[35]  XW[2;;]←WT
[36]  VK←S2,XX1[2],XX2[2],XX3[2]
[37]  VK CALCULO XW
```

VALOR4:

```
      ∇VALOR4[⎕]∇
[0]   VALOR4;X1;X2;X3;X4;W1;W2;W3;W4;XX1;XX2;XX3;XX4;XT;WT;P;⎕IO;S2;XW;VK
[1]    P←4
[2]    ' '
[3]    'SUBCARTERA 1'
[4]    '==========='
[5]    XX1←LEER 0
[6]    X1←XX1[1]LEERPOL XX1[2]
[7]    '============================================================'
[8]    '============================================================'
[9]    W1←XX1[1]LEERPES XX1[2]
[10]   ' '
[11]   'SUBCARTERA 2'
[12]   '==========='
[13]   XX2←LEER 0
[14]   X2←XX2[1]LEERPOL XX2[2]
[15]   '============================================================'
[16]   '============================================================'
[17]   W2←XX2[1]LEERPES XX2[2]
[18]   ' '
[19]   'SUBCARTERA 3'
[20]   '==========='
[21]   XX3←LEER 0
[22]   X3←XX3[1]LEERPOL XX3[2]
[23]   '============================================================'
[24]   '============================================================'
[25]   W3←XX3[1]LEERPES XX3[2]
[26]   ' '
[27]   'SUBCARTERA 4'
[28]   '==========='
```

```
[29]  XX4←LEER 0
[30]  X4←XX4[1]LEERPOL XX4[2]
[31]  '=========================================================='
[32]  '=========================================================='
[33]  W4←XX4[1]LEERPES XX4[2]
[34]  XT←X1,X2,X3,X4
[35]  WT←W1,W2,W3,W4
[36]  S2←XT SCUAD WT
[37]  XW←(2,(⍴XT))⍴0
[38]  XW[1;;]←XT
[39]  XW[2;;]←WT
[40]  VK←S2,XX1[2],XX2[2],XX3[2],XX4[2]
[41]  VK CALCULO XW
```

VALOR5:

```
      ▽VALOR5[⎕]▽
[0]   VALOR5;X1;X2;X3;X4;X5;XX1;XX2;XX3;XX4;XX5;W1;W2;W3;W4;W5;P;⎕IO;S2;XW;VK
[1]    P←5
[2]    ⎕IO←1
[3]    ' '
[4]    'SUBCARTERA 1'
[5]    '==========='
[6]    ' '
[7]    XX1←LEER 0
[8]    X1←XX1[1]LEERPOL XX1[2]
[9]    '=========================================================='
[10]   '=========================================================='
[11]   W1←XX1[1]LEERPES XX1[2]
[12]   ' '
[13]   'SUBCARTERA 2'
[14]   '==========='
[15]   ' '
[16]   XX2←LEER 0
[17]   X2←XX2[1]LEERPOL XX2[2]
[18]   '=========================================================='
[19]   '=========================================================='
[20]   W2←XX2[1]LEERPES XX2[2]
[21]   ' '
[22]   'SUBCARTERA 3'
[23]   '==========='
[24]   ' '
[25]   XX3←LEER 0
[26]   X3←XX3[1]LEERPOL XX3[2]
[27]   '=========================================================='
[28]   '=========================================================='
[29]   W3←XX3[1]LEERPES XX3[2]
[30]   ' '
[31]   'SUBCARTERA 4'
[32]   '==========='
[33]   ' '
[34]   XX4←LEER 0
[35]   X4←XX4[1]LEERPOL XX4[2]
[36]   '=========================================================='
[37]   '=========================================================='
[38]   W4←XX4[1]LEERPES XX4[2]
[39]   ' '
```

```
[40]  'SUBCARTERA 5'
[41]  '==========='
[42]  ' '
[43]  XX5←LEER 0
[44]  X5←XX5[1]LEERPOL XX5[2]
[45]  '============================================================='
[46]  '============================================================='
[47]  W5←XX5[1]LEERPES XX5[2]
[48]  XT←X1,X2,X3,X4,X5
[49]  WT←W1,W2,W3,W4,W5
[50]  S2←XT SCUAD WT
[51]  XW←(2,(⍴XT))⍴0
[52]  XW[1;;]←XT
[53]  XW[2;;]←WT
[54]  VK←S2,XX1[2],XX2[2],XX3[2],XX4[2],XX5[2]
[55]  VK CALCULO XW
```

La función **LEER** pide el número de pólizas y el número de periodos observados.

```
     ∇LEER[⎕]∇
[0]  X←LEER BIN;T;K;TE
[1]   ⎕IO←1
[2]   ⎕←TE←'CUANTAS POLIZAS CONSIDERAS:'
[3]   K←⍎(⍴TE)↓⎕
[4]   PEQUE←∼K<2
[5]   ' '
[6]   ⎕←TE←'CUANTOS PERIODOS CONSIDERAS:'
[7]   T←⍎(⍴TE)↓⎕
[8]   PEQUE←∼K<2+BIN
[9]   →0,X←T,K
[10] PEQUE:' '
[11]  'LAS DIMENSIONES SON DEMASIADO PEQUE[AS PARA EL CALCULO DE'
[12]  'PRIMAS MEDIANTE LA TEORIA DE LA CREDIBILIDAD'
[13]  →0
```

La función **LEERPOL** pide los valores de las t observaciones de cada póliza

```
     ∇LEERPOL[⎕]∇
[0]  X←T LEERPOL K;J;AY;TE
[1]   X←(T,K)⍴0
[2]   J←1
[3]  DIR1:' '
[4]   'INTRODUCE LOS ',(⍕T),' VALORES DE LA POLIZA ',(⍕J),':'
[5]   →ERROR×∼T≠⍴,AY←⍎⎕
[6]   X[;J]←AY
[7]   →DIR1×∼K≥J←J+1
[8]   →0
[9]  ERROR:' '
[10]  'HAS INTRODUCIDO ',(⍕⍴AY),' VALORES EN VEZ DE ',(⍕T),'.'
[11]  →DIR1,⍴⎕←'INTRODUCELOS DE NUEVO'
```

La función **LEERPES** pide los valores de los t pesos de cada póliza.

```
      ∇LEERPES[⎕]∇
[0]   W←T LEERPES K;AY;TE
[1]    W←(T,K)⍴0
[2]    J←1
[3]   DIR1:' '
[4]    'INTRODUCE LOS ',(⍕T),' PESOS DE LA POLIZA ',(⍕J),':'
[5]    →ERROR×⍳T≠⍴AY←,⍞
[6]    W[;J]←AY
[7]    →DIR1×⍳K≥J←J+1
[8]    →0
[9]   ERROR:' '
[10]   'HAS INTRODUCIDO ',(⍕⍴AY),' PESOS EN VEZ DE ',(⍕T),'.'
[11]   →DIR1,⍴⎕←'INTRODUCELOS DE NUEVO'
```

La función **SCUAD** calcula la varianza de las observaciones del modelo.

```
      ∇SCUAD[⎕]∇
[0]   S2←XT SCUAD WT;XPJW;XTD;⎕IO
[1]    ⎕IO←1
[2]    XPJW←(1↓⍴XT)⍴0
[3]    XPJW←(÷(+/WT))×(+/WT×XT)
[4]    XTD←(⍴XT)⍴XPJW
[5]    S2←(÷((1↓⍴XT)×((1↑⍴XT)-1)))×+/+/WT×((XT-XTD)*2)
```

La función **CALCULO** calcula los estimadores individuales, el estimador colectivo, los factores de credibilidad y los estimadores de credibilidad para cada póliza y para cada subcartera, y el valor de los estimadores de los parámetros estructurales a y b..

Al ser a y b dos pseudo-estimadores, ha sido necesario desarrollar un proceso iterativo para obtener cada uno de ellos. Ambos procesos se detienenen cuando la diferencia entre los valores del pseudo-estimador en la iteración k y k+1 es inferior a 0,00001 en valor absoluto, o bien cuando se han realizado setenta y cinco iteraciones sin cumplirse la condición anterior.

En el proceso iterativo del pseudo-estimador a, se calculan simultáneamente los valores de $Z_{p\cdot}$, X_{pzw} y Z_{pj}, y en el del pseudo-estimador b, los valores de $Z_{\cdot}$,X_{zzw} y Z_{p}.

```
      ∇CALCULO[⎕]∇
[0]   VK CALCULO XW;ZPJ;ZP;KV;XPJW;ZX;ZXS;XPZW;XXP;ZZJ;A;A1;ZPB;ZB;NP;NPJ;NNP;⎕I
O;Z1;IT;IB
[1]    ⎕IO←1
[2]    KV←+\(1↓VK)
[3]    ZPJ←(2↓(⍴XW))⍴1
[4]    ZP←((⍴VK)-1)⍴0
[5]    XPJW←(÷(+/XW[2;;]))×+/XW[1;;]×XW[2;;]
[6]    XPZW←((⍴VK)-1)⍴0
[7]    A←0
[8]    ZXS←((⍴VK)-1)⍴0
[9]    IT←0
[10]  ITERA:
[11]   IT←IT+1
[12]   Z1←VK TRANS ZPJ
[13]   ZP←+/Z1
[14]   ZX←ZPJ×XPJW
[15]   Z1←VK TRANS ZX
[16]   ZXS←+/Z1
[17]   XPZW←ZXS÷ZP
[18]   XXP←(1↓VK)/XPZW
[19]   A1←(÷(+/1↓(VK-1)))×(+/ZPJ×(XPJW-XXP)*2)
[20]   ZPJ←(÷(VK[1]+A1×+/XW[2;;]))×(A1×+/XW[2;;])
[21]   →FINA×⍳((0.00001≥|(A1-A))∨IT≥75)
[22]   A←A1
[23]   →ITERA
[24]  FINA:' '
[25]   Z1←VK TRANS ZPJ
[26]   ZP←+/Z1
[27]   ZX←ZPJ×XPJW
[28]   Z1←VK TRANS ZX
[29]   ZXS←+/Z1
[30]   XPZW←ZXS÷ZP
[31]   ZPB←((⍴VK)-1)⍴1
[32]   IB←0
[33]   B←0
[34]  ITERB:
[35]   IB←IB+1
[36]   ZB←+/ZPB
[37]   XZZW←(÷ZB)×+/ZPB×XPZW
[38]   B1←(÷(⍴(2↓VK)))×(+/ZPB×(XPZW-XZZW)*2)
[39]   ZPB←(B1×ZP)÷(A1+B1×ZP)
[40]   →FINB×⍳((0.00001≥|(B1-B))∨IB≥75)
[41]   B←B1
[42]   →ITERB
[43]  FINB:
[44]   ZB←+/ZPB
[45]   XZZW←(÷ZB)×+/ZPB×XPZW
[46]   NP←((1-ZPB)×XZZW)+(ZPB×XPZW)
[47]   NNP←(1↓VK)/NP
[48]   NPJ←(ZPJ×XPJW)+((1-ZPJ)×NNP)
[49]   RESJEW
```

La función **TRANS** es una función auxiliar para el cálculo de X_{pzw}, que desglosa por subcarteras el resultado del producto del vector fila $Z_{pj} \cdot X_{pjw}$.

```
      ∇TRANS[⎕]∇
[0]   X←VK TRANS Z;⎕IO;M;I;V;C;S;U
[1]    ⎕IO←1
[2]    M←⌈/(1↓VK)
[3]    V←(((⍴VK)-1),M)⍴0
[4]    X←(((⍴VK)-1),M)⍴0
[5]    I←1
[6]   DIR1:
[7]    U←VK[I+1]↑Z
[8]    C←(M-VK[I+1])/0
[9]    S←U,C
[10]   V[I;]←S
[11]   Z←VK[I+1]↓Z
[12]   →DIR1×⍳((⍴VK)-1)≥I←I+1
[13]   X←V
```

La función **RESJEW** da el formato de salida de los resultados de la función JEWELL.

```
      ∇RESJEW[⎕]∇
[0]   RESJEW;P;BLA;I;TOT
[1]    P←⍴KV
[2]    BLA←2 2⍴' '
[3]    'MODELO JERARQUICO DE JEWELL'
[4]    '**************************'
[5]    BLA
[6]    'NUMERO DE SUBCARTERAS CONSIDERADAS: ',(⍕P)
[7]    ' '
[8]    ' '
[9]    'NUMERO DE POLIZAS POR SUBCARTERA'
[10]   ' '
[11]   I←1
[12]  DIR1:
[13]   'SUBCARTERA ',(⍕I),': ',⍕VK[I+1]
[14]   →DIR1×⍳P≥I←I+1
[15]   TOT←+/(1↓VK)
[16]   BLA
[17]   'ESTIMADORES INDIVIDUALES PARA CADA POLIZA'
[18]   '========================================'
[19]   ' '
[20]   I←1
[21]  DIR2:
[22]   'POLIZA ',(⍕I),': ',⍕XPJW[I]
[23]   →DIR2×⍳TOT≥I←I+1
[24]   BLA
[25]   'ESTIMADORES AJUSTADOS DE CREDIBILIDAD PARA CADA POLIZA'
[26]   '====================================================='
[27]   ' '
[28]   I←1
[29]  DIR3:
[30]   'POLIZA ',(⍕I),': ',⍕NPJ[I]
[31]   →DIR3×⍳TOT≥I←I+1
[32]   BLA
[33]   'FACTORES DE CREDIBILIDAD PARA CADA POLIZA'
[34]   '========================================='
[35]   ' '
[36]   I←1
[37]  DIR4:
[38]   'POLIZA ',(⍕I),': ',⍕ZPJ[I]
[39]   →DIR4×⍳TOT≥I←I+1
[40]   BLA
[41]   'ESTIMADORES INDIVIDUALES PARA CADA SUBCARTERA'
[42]   '============================================='
[43]   ' '
```

```
[44]  I←1
[45] DIR5:
[46]  'SUBACARTERA ',(⍕I),': ',⍕XPZW[I]
[47]  →DIR5×⍳P≥I←I+1
[48]  BLA
[49]  'ESTIMADORES AJUSTADOS DE CREDIBILIDAD PARA CADA SUBCARTERA'
[50]  '=========================================================='
[51]  ' '
[52]  I←1
[53] DIR6:
[54]  'SUBCARTERA ',(⍕I),': ',⍕NP[I]
[55]  →DIR6×⍳P≥I←I+1
[56]  BLA
[57]  'FACTOR DE CREDIBILIDAD PARA CADA SUBCARTERA'
[58]  '=========================================='
[59]  ' '
[60]  I←1
[61] DIR7:
[62]  'SUBCARTERA ',(⍕I),': ',⍕ZPB[I]
[63]  →DIR7×⍳P≥I←I+1
[64]  BLA
[65]  'ESTIMADOR COLECTIVO:            XZZW = ',⍕XZZW
[66]  '=================='
[67]  BLA
[68]  'VARIANZA ESPERADA                 S2 = ',⍕S2
[69]  ' '
[70]  'VARIANZA ESPERADA DENTRO '
[71]  'DE LAS SUBCARTERAS                A  = ',⍕A1
[72]  'NUM. ITER.(MAX 75): ',⍕IT
[73]  ' '
[74]  'VARIANZA ENTRE LAS '
[75]  'SUBCARTERAS                       B  = ',⍕B1
[76]  'NUM. ITER.(MAX 75): ',⍕IB
[77]  →0
```

6.- MODELO DE REGRESION JERARQUICO DE SUNDT

La función **SUNDT** pide el número de subcarteras y el tipo de matriz A_{pj} y B_{pj} que deseamos utilizar: constantes o variables, y según el número de subcarteras que hayamos considerado invoca la función SUNDT2, SUNDT3, SUNDT4 o SUNDT5.

```
      ∇SUNDT[⎕]∇
[0]   SUNDT;P;⎕IO;TE;TM
[1]   ⍝ MODELO JERARQUICO DE SUNDT
[2]    'INTRODUCE EL NUMERO DE SUBCARTERAS (ENTRE 2 Y 5):'
[3]    P←⎕
[4]    ' '
[5]    'ESCOJE EL TIPO DE MATRICES  A y B.'
[6]    '        1. CONSTANTES'
[7]    '        2. VARIABLES'
[8]    TM←⎕
[9]    ' '
[10]   →(P=2)⍴VAL2
[11]   →(P=3)⍴VAL3
[12]   →(P=4)⍴VAL4
[13]   →(P=5)⍴VAL5
[14]   →0
[15]  VAL2:
[16]   SUNDT2
[17]   →0
[18]  VAL3:
[19]   SUNDT3
[20]   →0
[21]  VAL4:
[22]   SUNDT4
[23]   →0
[24]  VAL5:
[25]   SUNDT5
[26]   →0
```

Las funciones **SUNDT2**, **SUNDT3**, **SUNDT4** y **SUNDT5** recogen, para el caso de considerar dos, tres, cuatro o cinco subcarteras, la información de las funciones LEER, LEERPOL, CREAV, PONCOL, CREAY, MATRIZA y MATRIZB o MATRIZAV y MATRIZBV (según si hemos elegido las matrices A_{pj} y B_{pj} constantes o variables) para cada subcartera, y al mismo tiempo pide el valor numérico de $G_{\emptyset}^{*}$ y G_{1}^{*}.

SUNDT2:

```
      ∇SUNDT2[⎕]∇
[0]   SUNDT2;⎕IO;X1;X2;XX1;XX2;V1;V2;XP1;XP2;Y1;Y2;A1;A2;B1;B2;YT;XT;XTPJ;AP;BP;
K;VPJ;P;PGO;PG1
[1]    'SUBCARTERA 1:'
[2]    '=============='
[3]    XX1←LEER ⎕IO←1
[4]    X1←XX1[1]LEERPOL XX1[2]
[5]    '======================================'
[6]    V1←XX1[1]CREAV XX1[2]
[7]    XP1←(XX1[2],XX1[1],1)⍴0
[8]    XP1←PONCOL X1
[9]    Y1←(XX1[2],XX1[1],2)⍴0
[10]   Y1←CREAY XX1
[11]   A1←(XX1[2],XX1[1],2)⍴0
[12]   B1←(XX1[2],XX1[1],(XX1[1]-2))⍴0
[13]   →(TM=2)⍴MAB1
[14]   A1←MATRIZA XX1
[15]   B1←MATRIZB XX1
[16]   →WW21
```

```
[17] MAB1:
[18]  A1←Y1 MATRIZAV V1
[19]  B1←Y1 MATRIZBV V1
[20] WW21:
[21]  ' '
[22]  ' '
[23]  'SUBCARTERA 2:'
[24]  '=============='
[25]  XX2←LEER ⎕IO←1
[26]  ' '
[27]  X2←XX2[1]LEERPOL XX2[2]
[28]  '=========================================='
[29]  V2←XX2[1]CREAV XX2[2]
[30]  ' '
[31]  'INTRODUCCION DE DATOS COMPLEMENTARIOS'
[32]  '======================================'
[33]  ' '
[34]  'PARTE DE G0:'
[35]  P←⎕
[36]  PG0←2 2⍴,P
[37]  ' '
[38]  'PARTE DE G1:'
[39]  P←⎕
[40]  PG1←2 2⍴,P
[41]  ' '
[42]  ' '
[43]  XP2←(XX2[2],XX2[1],1)⍴0
[44]  XP2←PONCOL X2
[45]  Y2←(XX2[2],XX2[1],2)⍴0
[46]  Y2←CREAY XX2
[47]  A2←(XX2[2],XX2[1],2)⍴0
[48]  B2←(XX2[2],XX2[1],(XX2[1]-2))⍴0
[49]  →(TM=2)⍴MAB2
[50]  A2←MATRIZA XX2
[51]  B2←MATRIZB XX2
[52]  →WW22
[53] MAB2:
[54]  A2←Y2 MATRIZAV V2
[55]  B2←Y2 MATRIZBV V2
[56] WW22:
[57]  ' '
[58]  K←XX1[2],XX2[2]
[59]  YT←Y1,[1]Y2
[60]  XTPJ←XP1,[1]XP2
[61]  AP←A1,[1]A2
[62]  BP←B1,[1]B2
[63]  VPJ←V1,[1]V2
[64]  CALCSUNDT
```

SUNDT3:

```
      ▽SUNDT3[⎕]▽
[0]  SUNDT3;⎕IO;X1;X2;X3;XX1;XX2;XX3;V1;V2;V3;XP1;XP2;XP3;Y1;Y2;Y3;B1;B2;B3;YT;
XT;XTPJ;AP;BP;K;VPJ;P;PG0;PG1
[1]   'SUBCARTERA 1:'
[2]   '=============='
[3]   XX1←LEER ⎕IO←1
[4]   X1←XX1[1]LEERPOL XX1[2]
[5]   '=========================================================='
[6]   V1←XX1[1]CREAV XX1[2]
[7]   XP1←(XX1[2],XX1[1],1)⍴0
[8]   XP1←PONCOL X1
[9]   Y1←(XX1[2],XX1[1],2)⍴0
[10]  Y1←CREAY XX1
[11]  A1←(XX1[2],XX1[1],(XX1[1]-2))⍴0
[12]  B1←(XX1[2],XX1[1],(XX1[1]-2))⍴0
[13]  →(TM=2)⍴MAB1
```

```
[14]  A1←MATRIZA XX1
[15]  B1←MATRIZB XX1
[16]  →WW31
[17] MAB1:
[18]  A1←Y1 MATRIZAV V1
[19]  B1←Y1 MATRIZBV V1
[20] WW31:
[21]  ' '
[22]  'SUBCARTERA 2:'
[23]  '=============='
[24]  XX2←LEER ⎕IO←1
[25]  X2←XX2[1]LEERPOL XX2[2]
[26]  '=========================================================='
[27]  V2←XX2[1]CREAV XX2[2]
[28]  XP2←(XX2[2],XX2[1],1)⍴0
[29]  XP2←PONCOL X2
[30]  Y2←(XX2[2],XX2[1],2)⍴0
[31]  Y2←CREAY XX2
[32]  A2←(XX2[2],XX2[1],(XX2[1]-2))⍴0
[33]  B2←(XX2[2],XX2[1],(XX2[1]-2))⍴0
[34]  →(TM=2)⍴MAB2
[35]  A2←MATRIZA XX2
[36]  B2←MATRIZB XX2
[37]  →WW32
[38] MAB2:
[39]  A2←Y2 MATRIZAV V2
[40]  B2←Y2 MATRIZBV V2
[41] WW32:
[42]  ' '
[43]  'SUBCARTERA 3:'
[44]  '=============='
[45]  XX3←LEER ⎕IO←1
[46]  X3←XX3[1]LEERPOL XX3[2]
[47]  '=========================================================='
[48]  V3←XX3[1]CREAV XX3[2]
[49]  ' '
[50]  'INTRODUCCION DE DATOS COMPLEMENTARIOS'
[51]  '====================================='
[52]  ' '
[53]  'PARTE DE G0:'
[54]  P←⎕
[55]  PG0←2 2⍴,P
[56]  ' '
[57]  'PARTE DE G1:'
[58]  P←⎕
[59]  PG1←2 2⍴,P
[60]  ' '
[61]  XP3←(XX3[2],XX3[1],1)⍴0
[62]  XP3←PONCOL X3
[63]  Y3←(XX3[2],XX3[1],2)⍴0
[64]  Y3←CREAY XX3
[65]  A3←(XX3[2],XX3[1],(XX3[1]-2))⍴0
[66]  B3←(XX3[2],XX3[1],(XX3[1]-2))⍴0
[67]  →(TM=2)⍴MAB3
[68]  A3←MATRIZA XX3
[69]  B3←MATRIZB XX3
[70]  →WW33
[71] MAB3:
[72]  A3←Y3 MATRIZAV V3
[73]  B3←Y3 MATRIZBV V3
[74] WW33:
[75]  ' '
[76]  K←XX1[2],XX2[2],XX3[2]
[77]  YT←Y1,[1]Y2,[1]Y3
[78]  XTPJ←XP1,[1]XP2,[1]XP3
[79]  AP←A1,[1]A2,[1]A3
[80]  BP←B1,[1]B2,[1]B3
[81]  VPJ←V1,[1]V2,[1]V3
[82]  CALCSUNDT
```

SUNDT4:

```
      ∇SUNDT4[⎕]∇
[0]  SUNDT4;X1;X2;X3;X4;XX1;XX2;XX3;XX4;V1;V2;V3;V4;XP1;XP2;XP3;XP4;Y1;Y2;Y3;Y4
;A1;A2;A3;A4;B1;B2;B3;B4;YT;XT;XTPJ;K;VPJ;AP;BP;⎕IO;P;PG0;PG1
[1]    'SUBCARTERA 1:'
[2]    '=============='
[3]    XX1←LEER ⎕IO←1
[4]    X1←XX1[1]LEERPOL XX1[2]
[5]    '================================================='
[6]    V1←XX1[1]CREAV XX1[2]
[7]    XP1←(XX1[2],XX1[1],1)⍴0
[8]    XP1←PONCOL X1
[9]    Y1←(XX1[2],XX1[1],2)⍴0
[10]   Y1←CREAY XX1
[11]   A1←(XX1[2],XX1[1],2)⍴0
[12]   B1←(XX1[2],XX1[1],(XX1[1]-2))⍴0
[13]   →(TM=2)⍴MAB1
[14]   A1←MATRIZA XX1
[15]   B1←MATRIZB XX1
[16]   →WW41
[17]  MAB1:
[18]   A1←Y1 MATRIZAV V1
[19]   B1←Y1 MATRIZBV V1
[20]  WW41:
[21]   ' '
[22]   'SUBCARTERA 2:'
[23]   '=============='
[24]   XX2←LEER ⎕IO←1
[25]   X2←XX2[1]LEERPOL XX2[2]
[26]   '================================================='
[27]   V2←XX2[1]CREAV XX2[2]
[28]   XP2←(XX2[2],XX2[1],1)⍴0
[29]   XP2←PONCOL X2
[30]   Y2←(XX2[2],XX2[1],2)⍴0
[31]   Y2←CREAY XX2
[32]   A2←(XX2[2],XX2[1],2)⍴0
[33]   B2←(XX2[2],XX2[1],(XX2[1]-2))⍴0
[34]   →(TM=2)⍴MAB2
[35]   A2←MATRIZA XX2
[36]   B2←MATRIZB XX2
[37]   →WW42
[38]  MAB2:
[39]   A2←Y2 MATRIZAV V2
[40]   B2←Y2 MATRIZBV V2
[41]  WW42:
[42]   ' '
[43]   'SUBCARTERA 3:'
[44]   '=============='
[45]   XX3←LEER ⎕IO←1
[46]   X3←XX3[1]LEERPOL XX3[2]
[47]   '================================================='
[48]   V3←XX3[1]CREAV XX3[2]
[49]   XP3←(XX3[2],XX3[1],1)⍴0
[50]   XP3←PONCOL X3
[51]   Y3←(XX3[2],XX3[1],2)⍴0
[52]   Y3←CREAY XX3
[53]   A3←(XX3[2],XX3[1],2)⍴0
[54]   B3←(XX3[2],XX3[1],(XX3[1]-2))⍴0
[55]   →(TM=2)⍴MAB3
[56]   A3←MATRIZA XX3
[57]   B3←MATRIZB XX3
[58]   →WW43
[59]  MAB3:
[60]   A3←Y3 MATRIZAV V3
[61]   B3←Y3 MATRIZBV V3
```

```
[62] WW43:
[63]  ' '
[64]  'SUBCARTERA 4:'
[65]  '=============='
[66]  XX4←LEER ⎕IO←1
[67]  X4←XX4[1]LEERPOL XX4[2]
[68]  '================================================='
[69]  V4←XX4[1]CREAV XX4[2]
[70]  ' '
[71]  'INTRODUCCION DE DATOS COMPLEMENTARIOS'
[72]  '======================================'
[73]  ' '
[74]  'PARTE DE G0:'
[75]  P←⎕
[76]  PG0←2 2⍴,P
[77]  ' '
[78]  'PARTE DE G1:'
[79]  P←⎕
[80]  PG1←2 2⍴,P
[81]  ' '
[82]  XP4←(XX4[2],XX4[1],1)⍴0
[83]  XP4←PONCOL X4
[84]  Y4←(XX4[2],XX4[1],2)⍴0
[85]  Y4←CREAY XX4
[86]  A4←(XX4[2],XX4[1],2)⍴0
[87]  B4←(XX4[2],XX4[1],(XX4[1]-2))⍴0
[88]  →(TM=2)⍴MAB4
[89]  A4←MATRIZA XX4
[90]  B4←MATRIZB XX4
[91]  →WW44
[92] MAB4:
[93]  A4←Y4 MATRIZAV V4
[94]  B4←Y4 MATRIZBV V4
[95] WW44:
[96]  K←XX1[2],XX2[2],XX3[2],XX4[2]
[97]  YT←Y1,[1]Y2,[1]Y3,[1]Y4
[98]  XTPJ←XP1,[1]XP2,[1]XP3,[1]XP4
[99]  AP←A1,[1]A2,[1]A3,[1]A4
[100] BP←B1,[1]B2,[1]B3,[1]B4
[101] VPJ←V1,[1]V2,[1]V3,[1]V4
[102] CALCSUNDT
```

SUNDT5:

```
      ∇SUNDT5[⎕]∇
[0]  SUNDT5;X1;X2;X3;X4;X5;XX1;XX2;XX3;XX4;XX5;V1;V2;V3;V4;V5;Y1;Y2;Y3;Y4;Y5;A1
;A2;A3;A4;A5;B1;B2;B3;B4;B5;YT;XT;XTPJ;AP;BP;K;VPJ;⎕IO;P;PG0;PG1
[1]   'SUBCARTERA 1:'
[2]   '=============='
[3]   XX1←LEER ⎕IO←1
[4]   X1←XX1[1]LEERPOL XX1[2]
[5]   '================================================='
[6]   V1←XX1[1]CREAV XX1[2]
[7]   XP1←(XX1[2],XX1[1],1)⍴0
[8]   XP1←PONCOL X1
[9]   Y1←(XX1[2],XX1[1],2)⍴0
[10]  Y1←CREAY XX1
[11]  A1←(XX1[2],XX1[1],2)⍴0
[12]  B1←(XX1[2],XX1[1],(XX1[1]-2))⍴0
[13]  →(TM=2)⍴MAB1
[14]  A1←MATRIZA XX1
[15]  B1←MATRIZB XX1
[16]  →WW51
[17] MAB1:
[18]  A1←Y1 MATRIZAV V1
[19]  B1←Y1 MATRIZBV V1
```

```
[20] WW51:
[21]  ' '
[22]  'SUBCARTERA 2:'
[23]  '=============='
[24]  XX2←LEER ⎕IO←1
[25]  X2←XX2[1]LEERPOL XX2[2]
[26]  '================================================='
[27]  V2←XX2[1]CREAV XX2[2]
[28]  XP2←(XX2[2],XX2[1],1)⍴0
[29]  XP2←PONCOL X2
[30]  Y2←(XX2[2],XX2[1],2)⍴0
[31]  Y2←CREAY XX2
[32]  A2←(XX2[2],XX2[1],2)⍴0
[33]  B2←(XX2[2],XX2[1],(XX2[1]-2))⍴0
[34]  →(TM=2)⍴MAB2
[35]  A2←MATRIZA XX2
[36]  B2←MATRIZB XX2
[37]  →WW52
[38] MAB2:
[39]  A2←Y2 MATRIZAV V2
[40]  B2←Y2 MATRIZBV V2
[41] WW52:
[42]  ' '
[43]  'SUBCARTERA 3:'
[44]  '=============='
[45]  XX3←LEER ⎕IO←1
[46]  X3←XX3[1]LEERPOL XX3[2]
[47]  '================================================='
[48]  V3←XX3[1]CREAV XX3[2]
[49]  XP3←(XX3[2],XX3[1],1)⍴0
[50]  XP3←PONCOL X3
[51]  Y3←(XX3[2],XX3[1],2)⍴0
[52]  Y3←CREAY XX3
[53]  A3←(XX3[2],XX3[1],2)⍴0
[54]  B3←(XX3[2],XX3[1],(XX3[1]-2))⍴0
[55]  →(TM=2)⍴MAB3
[56]  A3←MATRIZA XX3
[57]  B3←MATRIZB XX3
[58]  →WW53
[59] MAB3:
[60]  A3←Y3 MATRIZAV V3
[61]  B3←Y3 MATRIZBV V3
[62] WW53:
[63]  ' '
[64]  'SUBCARTERA 4:'
[65]  '=============='
[66]  XX4←LEER ⎕IO←1
[67]  X4←XX4[1]LEERPOL XX4[2]
[68]  '================================================='
[69]  V4←XX4[1]CREAV XX4[2]
[70]  XP4←(XX4[2],XX4[1],1)⍴0
[71]  XP4←PONCOL X4
[72]  Y4←(XX4[2],XX4[1],2)⍴0
[73]  Y4←CREAY XX4
[74]  A4←(XX4[2],XX4[1],2)⍴0
[75]  B4←(XX4[2],XX4[1],(XX4[1]-2))⍴0
[76]  →(TM=2)⍴MAB4
[77]  A4←MATRIZA XX4
[78]  B4←MATRIZB XX4
[79]  →WW54
[80] MAB4:
[81]  A4←Y4 MATRIZAV V4
[82]  B4←Y4 MATRIZBV V4
[83] WW54:
[84]  ' '
```

```
[85]  'SUBCARTERA 5:'
[86]  '=============='
[87]  XX5←LEER ⎕IO←1
[88]  X5←XX5[1]LEERPOL XX5[2]
[89]  '=============================================='
[90]  V5←XX5[1]CREAV XX5[2]
[91]  ' '
[92]  'INTRODUCCION DE DATOS COMPLEMENTARIOS'
[93]  '====================================='
[94]  ' '
[95]  'PARTE DE G0:'
[96]  P←⎕
[97]  PG0←2 2⍴,P
[98]  ' '
[99]  'PARTE DE G1:'
[100] P←⎕
[101] PG1←2 2⍴,P
[102] ' '
[103] XP5←(XX5[2],XX5[1],1)⍴0
[104] XP5←PONCOL X5
[105] Y5←(XX5[2],XX5[1],2)⍴0
[106] Y5←CREAY XX5
[107] A5←(XX5[2],XX5[1],2)⍴0
[108] B5←(XX5[2],XX5[1],(XX5[1]-2))⍴0
[109] →(TM=2)⍴MAB5
[110] A5←MATRIZA XX5
[111] B5←MATRIZB XX5
[112] →WW55
[113]MAB5:
[114] A5←Y5 MATRIZAV V5
[115] B5←Y5 MATRIZBV V5
[116]WW55:
[117] K←XX1[2],XX2[2],XX3[2],XX4[2],XX5[2]
[118] YT←Y1,[1]Y2,[1]Y3,[1]Y4,[1]Y5
[119] XTPJ←XP1,[1]XP2,[1]XP3,[1]XP4,[1]XP5
[120] AP←A1,[1]A2,[1]A3,[1]A4,[1]A5
[121] BP←B1,[1]B2,[1]B3,[1]B4,[1]B5
[122] VPJ←V1,[1]V2,[1]V3,[1]V4,[1]V5
[123] CALCSUNDT
```

La función **LEER** pide el número de pólizas y el número de periodos observados.

```
     ∇LEER[⎕]∇
[0]  X←LEER BIN;T;K;TE
[1]   ⎕IO←1
[2]   ⎕←TE←'CUANTAS POLIZAS CONSIDERAS:'
[3]   K←⍎(⍴TE)↓⎕
[4]   PEQUE←~K<2
[5]   ' '
[6]   ⎕←TE←'CUANTOS PERIODOS CONSIDERAS:'
[7]   T←⍎(⍴TE)↓⎕
[8]   PEQUE←~K<2+BIN
[9]   →0,X←T,K
[10] PEQUE:' '
[11]  'LAS DIMENSIONES SON DEMASIADO PEQUE[AS PARA EL CALCULO DE'
[12]  'PRIMAS MEDIANTE LA TEORIA DE LA CREDIBILIDAD'
[13]  →0
```

La función **LEERPOL** pide los valores de las t observaciones de cada póliza

```
      ∇LEERPOL[⎕]∇
[0]   X←T LEERPOL K;J;AY;TE
[1]    X←(T,K)⍴0
[2]    J←1
[3]   DIR1:' '
[4]    'INTRODUCE LOS ',(⍕T),' VALORES DE LA POLIZA ',(⍕J),':'
[5]    →ERROR×⍳T≠⍴,AY←⍎⎕
[6]    X[;J]←AY
[7]    →DIR1×⍳K≥J←J+1
[8]    →0
[9]   ERROR:' '
[10]   'HAS INTRODUCIDO ',(⍕⍴AY),' VALORES EN VEZ DE ',(⍕T),'.'
[11]   →DIR1,⍴⎕←'INTRODUCELOS DE NUEVO'
```

La función **CREAV** pide los t valores de los pesos de cada póliza y genera la matriz $v_{pj} = \text{diag}(w_{pj1}, w_{pj2}, \ldots, w_{pjt})$.

```
      ∇CREAV[⎕]∇
[0]   V←T CREAV K;J;A;TE;⎕IO
[1]    ⎕IO←1
[2]    V←(K,T,T)⍴0
[3]    ⍳0
[4]    J←1
[5]    ' '
[6]   DIR1:
[7]    ' '
[8]    'INTRODUCE LOS ',(⍕T),' PESOS DE LA SUCURSAL ',(⍕J),':'
[9]    →ERROR×⍳T≠⍴A←,⍎⎕
[10]   V[J;;1]←A
[11]   V[J;;]←(⍉⍳T)⍉V[J;;]
[12]   →DIR1×⍳K≥J←J+1
[13]   →0
[14]  ERROR:⍳0
[15]   'HAS INTRODUCIDO ',(⍕⍴A),' PESOS EN VES DE ',(⍕T),'.'
[16]   →DIR1,⍴⎕←'INTRODUCELOS DE NUEVO'
```

La función **CREAY** genera la matriz $Y_{pj} = \begin{bmatrix} 1 & t \\ 1 & t-1 \\ \vdots & \vdots \\ 1 & 1 \end{bmatrix}$.

```
      ∇CREAY[⎕]∇
[0]   Y←CREAY X;Y1;⎕IO;J
[1]    ⎕IO←1
[2]    Y←(X[2],X[1],2)⍴0
[3]    J←1
[4]   DIR1:
[5]    Y[J;;]←(⍉⍳X[1])∘.*0 1
[6]    →DIR1×⍳X[2]≥J←J+1
[7]    →0
```

La función **PONCOL** es una función auxiliar que genera una matriz columna con los valores de las observaciones de cada subcartera.

```
      ∇PONCOL[⎕]∇
[0]   X←PONCOL Y;⎕IO;T;K
[1]    T←1↑⍴Y
[2]    K←1↓⍴Y
[3]    X←(K,T,1)⍴,⍉Y
[4]    →0
```

La función **MATRIZA** genera la matriz constante $A = \begin{bmatrix} 1 & -3 \\ 1 & -1 \\ 1 & 1 \\ 1 & 3 \end{bmatrix}$.

```
      ∇MATRIZA[⎕]∇
[0]   A←MATRIZA X;⎕IO;F;FN;COL;UN;J;N;T;K
[1]    ⎕IO←1
[2]    T←1↑X
[3]    K←1↓X
[4]    →((2|T)=0)⍴APAR
[5]    →((2|T)=1)⍴AIMP
[6]    →0
[7]   APAR:
[8]    N←T÷2
[9]    F←¯1+(2×⍳N)
[10]   FN←¯1×F
[11]   FN←FN[⍋FN]
[12]   COL←FN,F
[13]   →CREAA
[14]  AIMP:
[15]   N←⌊(T÷2)
[16]   F←⍳N
[17]   FN←¯1×F
[18]   FN←FN[⍋FN]
[19]   COL←FN,0,F
[20]  CREAA:
[21]   A←(K,T,2)⍴0
[22]   UN←T⍴1
[23]   J←1
[24]  DIR1:
[25]   A[J;;1]←UN
[26]   A[J;;2]←COL
[27]   →DIR1×⍳K≥J←J+1
[28]   →0
```

La función **MATRIZAV** genera la matriz variable $A'_{pj} = Y'_{pj} \cdot v_{pj}$.

```
      ∇MATRIZAV[⎕]∇
[0]   A←Y MATRIZAV V;⎕IO;R;J
[1]    ⎕IO←1
[2]    R←1↑(⍴Y)
[3]    A←(⍴Y)⍴0
[4]    J←1
[5]   DIR:
[6]    A[J;;]←V[J;;]+.×Y[J;;]
[7]    →DIR×⍳R≥J←J+1
[8]    →0
```

La función **MATRIZB** genera la matriz constante B = $\begin{bmatrix} 1 & 2 \\ -2 & -3 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}$.

```
      ∇MATRIZB[⎕]∇
[0]   B←MATRIZB X;BI;F;T;FN;V;UN;K;J;⎕IO
[1]    ⎕IO←1
[2]    T←1↑X
[3]    K←1↓X
[4]    BI←(2,(T-2))⍴0
[5]    BI[1;]←⍳(T-2)
[6]    F←⍳(T-1)
[7]    FN←⁻1×(1↓F)
[8]    BI[2;]←FN
[9]    V←1,(T-2)⍴0
[10]   UN←((T-2),(T-2))⍴V
[11]   B←(K,T,(T-2))⍴0
[12]   J←1
[13]  DIR1:
[14]   B[J;;]←BI,[1]UN
[15]   →DIR1×⍳K≥J←J+1
[16]   →0
```

La función **MATRIZBV** genera el producto de matrices $B_{pj} \cdot B'_{pj}$, cuando la matriz B_{pj} es variable, producto que viene definido del siguiente modo: $B_{pj} \cdot B'_{pj} = v_{pj} - v_{pj} \cdot Y_{pj} \cdot (Y'_{pj} \cdot v_{pj} \cdot Y_{pj})^{-1} \cdot Y'_{pj} \cdot v_{pj}$.

```
      ∇MATRIZBV[⎕]∇
[0]   B←Y MATRIZBV V;⎕IO;J;R
[1]    ⎕IO←1
[2]    R←1↑(⍴V)
[3]    B←(⍴V)⍴0
[4]    J←1
[5]   DIR:
[6]    B[J;;]←V[J;;]-(V[J;;]+.×Y[J;;]+.×(⌹((⍉Y[J;;])+.×V[J;;]+.×Y[J;;]))+.×(⍉Y[J
;;])+.×V[J;;])
[7]    →DIR×⍳R≥J←J+1
[8]    →0
```

La función **CALCSUNDT** calcula el estimador de la varianza $\hat{S}^2$; la matriz de covarianzas ϕ_{pj}^{-1} que, siguiendo a NORBERG, R. (1976), hemos asumido que viene definida del siguiente modo: $\phi_{pj} = S^2 \cdot v_{pj}^{-1}$, siendo $v_{pj}^{-1} = \text{diag}(\frac{1}{w_{pj1}}, \frac{1}{w_{pj2}}, \ldots, \frac{1}{w_{pjt}})$, el vector de los estimadores mínimo-cuadrado generalizados de los coeficientes de regresión para cada póliza, la matriz de covarianzas de los valores esperados de los coeficientes de regresión Λ_p y Λ, y las matrices G_0, G_1, G_2 y H.

```
      ∇CALCSUNDT[⎕]∇
[0]   CALCSUNDT;⎕IO;BET;ALF;FIPJ;S2;BEPJ;AX;J;SAX;SAY;IN1;UN;TRA;IN2;G0;G1;G2;H;
M1;M2;M3;L;LP
[1]    ⎕IO←1
[2]    AX←((+/K),2,1)⍴0
[3]    J←1
[4]   DIR1:
[5]    AX[J;;]←(⍉AP[J;;])+.×XTPJ[J;;]
[6]    →DIR1×⍳(+/K)≥J←J+1
[7]    SAX←+/[1]AX
[8]    AY←((+/K),2,2)⍴0
[9]    J←1
[10]  DIR2:
[11]   AY[J;;]←(⍉AP[J;;])+.×YT[J;;]
[12]   →DIR2×⍳(+/K)≥J←J+1
[13]   SAY←+/[1]AY
[14]   ' '
[15]   BET←(⌹SAY)+.×SAX
[16]   ALF←((+/K),1)⍴0
[17]   →(TM=2)⍴SAL1
[18]   J←1
[19]  DIR3:
[20]   ALF[J;]←(⍉XTPJ[J;;])+.×(BP[J;;]+.×((⍉BP[J;;])+.×XTPJ[J;;]))
[21]   →DIR3×⍳(+/K)≥J←J+1
[22]   →BOTA1
[23]  SAL1:
[24]   J←1
[25]  DIR33:
[26]   ALF[J;]←(⍉XTPJ[J;;])+.×(BP[J;;]+.×XTPJ[J;;])
[27]   →DIR33×⍳(+/K)≥J←J+1
[28]  BOTA1:
[29]  ⍝ CALCULO DE S2
[30]   IN1←((+/K),XX1[1],XX1[1])⍴0
[31]   →(TM=2)⍴SAL2
[32]   J←1
[33]  DIR4:
[34]   IN1[J;;]←BP[J;;]+.×((⍉BP[J;;])+.×⌹VPJ[J;;])
[35]   →DIR4×⍳(+/K)≥J←J+1
[36]   →BOTA2
[37]  SAL2:
[38]   J←1
[39]  DIR44:
[40]   IN1[J;;]←BP[J;;]+.×⌹VPJ[J;;]
[41]   →DIR44×⍳(+/K)≥J←J+1
[42]  BOTA2:
[43]   UN←(XX1[1],XX1[1])⍴1,(XX1[1])⍴0
[44]   TRA←((+/K),XX1[1],XX1[1])⍴0
[45]   J←1
[46]  DIR5:
[47]   TRA[J;;]←UN
[48]   →DIR5×⍳(+/K)≥J←J+1
[49]   IN2←,TRA
[50]   S2←(+/ALF)÷(+/(IN2/,IN1))
[51]   FIPJ←(⍴VPJ)⍴0
[52]   J←1
[53]   FIPJ←VPJ÷S2
[54]   BEPJ←((+/K),1,2)⍴0
[55]   J←1
[56]  DIR6:
[57]   BEPJ[J;;]←(⍉XTPJ[J;;])+.×(FIPJ[J;;]+.×(YT[J;;]+.×⌹((⍉YT[J;;])+.×(FIPJ[J;;
]+.×YT[J;;]))))
[58]   →DIR6×⍳(+/K)≥J←J+1
[59]  ⍝ CALCULO DE G0, G1, G2 y H
[60]   J←1
[61]   M1←((+/K),2,2)⍴0
[62]   M2←((+/K),2,2)⍴0
[63]   M3←((+/K),2,2)⍴0
```

```
[64] DIR7:
[65]  M1[J;;]←(⍉YT[J;;])+.×AP[J;;]
[66]  M2[J;;]←(⊞((⍉AP[J;;])+.×YT[J;;]))+.×((⍉AP[J;;])+.×(XTPJ[J;;]+.×(⍉XTPJ[J;;
]))+.×AP[J;;])
[67]  M3[J;;]←(⊞((⍉AP[J;;])+.×YT[J;;]))+.×((⍉AP[J;;])+.×(⊞VPJ[J;;])+.×AP[J;;])
[68]  →DIR7×⍳(+/K)≥J←J+1
[69]  G2←2 2⍴0
[70]  G2←(+/[1]M2)+.×⊞(+/[1]M1)
[71]  H←2 2⍴0
[72]  H←(+/[1]M3)+.×⊞(+/[1]M1)
[73]  G1←2 2⍴0
[74]  G1←PG1+.×⊞(+/[1]M1)
[75]  G0←2 2⍴0
[76]  G0←PG0+.×⊞(+/[1]M1)
[77]  L←((⍉G1)+G1-((⍉G0)+G0))÷2
[78]  →(L[1;1]≥0)⍴DWQ
[79]  L[1;1]←0
[80] DWQ:
[81]  →(L[2;2]≥0)⍴DAQ
[82]  L[2;2]←0
[83] DAQ:
[84]  LP←(((⍉G2)+G2-((⍉G1)+G1))-(S2×((⍉H)+H)))÷2
[85]  →(LP[1;1]≥0)⍴DES
[86]  LP[1;1]←0
[87] DES:
[88]  →(LP[2;2]≥0)⍴DAS
[89]  LP[2;2]←0
[90] DAS:
[91]  ESTIM1
```

La función **ESTIM1** calcula los factores de credibilidad individuales los estimadores mínimo-cuadrado generalizados de los coeficientes de regresión y los factores de credibilidad para cada subcartera, para los casos en que la cartera se haya dividido en dos o tres subcarteras.

```
      ▽ESTIM1[⎕]▽
[0]  ESTIM1;⎕IO;BEP;TK;ZPJ;I;PP;OO;P1;P2;P3;O1;O2;O3;ZP;H1
[1]   ⎕IO←1
[2]   J←1
[3]   I←2 2⍴1 0 0
[4]   ZPJ←((+/K),2,2)⍴0
[5]  DIR8:
[6]   H1←I+((⍉YT[J;;])+.×FIPJ[J;;]+.×YT[J;;]+.×LP)
[7]   ZPJ[J;;]←((⍉YT[J;;])+.×(FIPJ[J;;]+.×(YT[J;;]+.×LP)))+.×⊞H1
[8]   H1←⍳0
[9]   →DIR8×⍳(+/K)≥J←J+1
[10]  ZP←((⍴K),2,2)⍴0
[11]  BEP←((⍴K),1,2)⍴0
[12]  TK←+\K
[13]  PP←((+/K),2,2)⍴0
[14]  OO←((+/K),1,2)⍴0
[15]  J←1
```

```
[16] DIRA:
[17]  PP[J;;]←(⍉YT[J;;])+.×(⊞((⊞FIPJ[J;;])+(YT[J;;]+.×LP+.×(⍉YT[J;;]))))+.×YT[J
;;]
[18]  OO[J;;]←(⍉XTPJ[J;;])+.×(⊞((⊞FIPJ[J;;])+(YT[J;;]+.×LP+.×(⍉YT[J;;]))))+.×YT
[J;;]
[19]  →DIRA×⍳(+/K)⋄J←J+1
[20]  →((⍴K)=2)⍴DOS
[21]  →((⍴K)=3)⍴TRES
[22]  ESTIM2
[23] DOS:
[24]  J←1
[25]  P1←(K[1],2,2)⍴0
[26]  O1←(K[1],1,2)⍴0
[27]  P2←(K[2],2,2)⍴0
[28]  O2←(K[2],1,2)⍴0
[29] DIRD1:
[30]  P1[J;;]←PP[J;;]
[31]  O1[J;;]←OO[J;;]
[32]  →DIRD1×⍳(K[1])⋄J←J+1
[33]  PP←(K[1],0,0)↓PP
[34]  OO←(K[1],0,0)↓OO
[35]  J←1
[36] DIRD2:
[37]  P2[J;;]←PP[J;;]
[38]  O2[J;;]←OO[J;;]
[39]  →DIRD2×⍳(K[2])⋄J←J+1
[40]  BEP[1;;]←(+/[1]O1)+.×(⊞(+/[1]P1))
[41]  BEP[2;;]←(+/[1]O2)+.×(⊞(+/[1]P2))
[42]  ZP[1;;]←(+/[1]P1)+.×L+.×(⊞(I+(+/[1]P1)+.×L))
[43]  ZP[2;;]←(+/[1]P2)+.×L+.×(⊞(I+(+/[1]P2)+.×L))
[44]  ESTIM3
[45]  →0
[46] TRES:
[47]  P1←(K[1],2,2)⍴0
[48]  O1←(K[1],1,2)⍴0
[49]  P2←(K[2],2,2)⍴0
[50]  O2←(K[2],1,2)⍴0
[51]  P3←(K[3],2,2)⍴0
[52]  O3←(K[3],1,2)⍴0
[53]  J←1
[54] DIRT1:
[55]  P1[J;;]←PP[J;;]
[56]  O1[J;;]←OO[J;;]
[57]  →DIRT1×⍳(K[1])⋄J←J+1
[58]  PP←(K[1],0,0)↓PP
[59]  OO←(K[1],0,0)↓OO
[60]  J←1
[61] DIRT2:
[62]  P2[J;;]←PP[J;;]
[63]  O2[J;;]←OO[J;;]
[64]  →DIRT2×⍳(K[2])⋄J←J+1
[65]  PP←(K[2],0,0)↓PP
[66]  OO←(K[2],0,0)↓OO
[67]  J←1
[68] DIRT3:
[69]  P3[J;;]←PP[J;;]
[70]  O3[J;;]←OO[J;;]
[71]  →DIRT3×⍳(K[3])⋄J←J+1
[72]  BEP[1;;]←(+/[1]O1)+.×(⊞(+/[1]P1))
[73]  BEP[2;;]←(+/[1]O2)+.×(⊞(+/[1]P2))
[74]  BEP[3;;]←(+/[1]O3)+.×(⊞(+/[1]P3))
[75]  ZP[1;;]←(+/[1]P1)+.×L+.×(⊞(I+(+/[1]P1)+.×L))
[76]  ZP[2;;]←(+/[1]P2)+.×L+.×(⊞(I+(+/[1]P2)+.×L))
[77]  ZP[3;;]←(+/[1]P3)+.×L+.×(⊞(I+(+/[1]P3)+.×L))
[78]  ESTIM3
[79]  →0
```

La función **ESTIM2** calcula los estimadores mínimo-cuadrado generalizados de los coeficientes de regresión y el factor de credibilidad para cada subcartera, para los casos de que la cartera se haya dividido en cuatro o cinco subcarteras.

```
      ▽ESTIM2[⎕]▽
[0]   ESTIM2;⎕IO;P1;P2;P3;P4;P5;O1;O2;O3;O4;O5
[1]    ⎕IO←1
[2]    →((⍴K)=4)⍴CUATRO
[3]    →((⍴K)=5)⍴CINCO
[4]    →0
[5]   CUATRO:
[6]    P1←(K[1],2,2)⍴0
[7]    P2←(K[2],2,2)⍴0
[8]    P3←(K[3],2,2)⍴0
[9]    P4←(K[4],2,2)⍴0
[10]   O1←(K[1],1,2)⍴0
[11]   O2←(K[2],1,2)⍴0
[12]   O3←(K[3],1,2)⍴0
[13]   O4←(K[4],1,2)⍴0
[14]   J←1
[15]  DIRU1:
[16]   P1[J;;]←PP[J;;]
[17]   O1[J;;]←OO[J;;]
[18]   →DIRU1×⍳(K[1])⌈J←J+1
[19]   PP←(K[1],0,0)↓PP
[20]   OO←(K[1],0,0)↓OO
[21]   J←1
[22]  DIRU2:
[23]   P2[J;;]←PP[J;;]
[24]   O2[J;;]←OO[J;;]
[25]   →DIRU2×⍳(K[2])⌈J←J+1
[26]   PP←(K[2],0,0)↓PP
[27]   OO←(K[2],0,0)↓OO
[28]   J←1
[29]  DIRU3:
[30]   P3[J;;]←PP[J;;]
[31]   O3[J;;]←OO[J;;]
[32]   →DIRU3×⍳(K[3])⌈J←J+1
[33]   PP←(K[3],0,0)↓PP
[34]   OO←(K[3],0,0)↓OO
[35]   J←1
[36]  DIRU4:
[37]   P4[J;;]←PP[J;;]
[38]   O4[J;;]←OO[J;;]
[39]   →DIRU4×⍳(K[4])⌈J←J+1
[40]   BEP[1;;]←(+/[1]O1)+.×⌹(+/[1]P1)
[41]   BEP[2;;]←(+/[1]O2)+.×⌹(+/[1]P2)
[42]   BEP[3;;]←(+/[1]O3)+.×⌹(+/[1]P3)
[43]   BEP[4;;]←(+/[1]O4)+.×⌹(+/[1]P4)
[44]   ZP[1;;]←(+/[1]P1)+.×L+.×⌹(I+(+/[1]P1)+.×L)
[45]   ZP[2;;]←(+/[1]P2)+.×L+.×⌹(I+(+/[1]P2)+.×L)
[46]   ZP[3;;]←(+/[1]P3)+.×L+.×⌹(I+(+/[1]P3)+.×L)
[47]   ZP[4;;]←(+/[1]P4)+.×L+.×⌹(I+(+/[1]P4)+.×L)
[48]   ESTIM3
[49]   →0
[50]  CINCO:
[51]   P1←(K[1],2,2)⍴0
[52]   P2←(K[2],2,2)⍴0
[53]   P3←(K[3],2,2)⍴0
[54]   P4←(K[4],2,2)⍴0
[55]   P5←(K[5],2,2)⍴0
[56]   O1←(K[1],1,2)⍴0
```

```
[57]  O2←(K[2],1,2)⍴0
[58]  O3←(K[3],1,2)⍴0
[59]  O4←(K[4],1,2)⍴0
[60]  O5←(K[5],1,2)⍴0
[61]  J←1
[62] DIRI1:
[63]  P1[J;;]←PP[J;;]
[64]  O1[J;;]←OO[J;;]
[65]  →DIRI1×⍳(K[1])≥J←J+1
[66]  PP←(K[1],0,0)↓PP
[67]  OO←(K[1],0,0)↓OO
[68]  J←1
[69] DIRU2:
[70]  P2[J;;]←PP[J;;]
[71]  O2[J;;]←OO[J;;]
[72]  →DIRU2×⍳(K[2])≥J←J+1
[73]  PP←(K[2],0,0)↓PP
[74]  OO←(K[2],0,0)↓OO
[75]  J←1
[76] DIRI3:
[77]  P3[J;;]←PP[J;;]
[78]  O3[J;;]←OO[J;;]
[79]  →DIRI3×⍳(K[3])≥J←J+1
[80]  PP←(K[3],0,0)↓PP
[81]  OO←(K[3],0,0)↓OO
[82]  J←1
[83] DIRI4:
[84]  P4[J;;]←PP[J;;]
[85]  O4[J;;]←OO[J;;]
[86]  →DIRI4×⍳(K[4])≥J←J+1
[87]  PP←(K[4],0,0)↓PP
[88]  OO←(K[4],0,0)↓OO
[89]  J←1
[90] DIRI5:
[91]  P5[J;;]←PP[J;;]
[92]  O5[J;;]←OO[J;;]
[93]  →DIRI5×⍳(K[5])≥J←J+1
[94]  BEP[1;;]←(+/[1]O1)+.×⌹(+/[1]P1)
[95]  BEP[2;;]←(+/[1]O2)+.×⌹(+/[1]P2)
[96]  BEP[3;;]←(+/[1]O3)+.×⌹(+/[1]P3)
[97]  BEP[4;;]←(+/[1]O4)+.×⌹(+/[1]P4)
[98]  BEP[5;;]←(+/[1]O5)+.×⌹(+/[1]P5)
[99]  ZP[1;;]←(+/[1]P1)+.×L+.×⌹(I+(+/[1]P1)+.×L)
[100] ZP[2;;]←(+/[1]P2)+.×L+.×⌹(I+(+/[1]P2)+.×L)
[101] ZP[3;;]←(+/[1]P3)+.×L+.×⌹(I+(+/[1]P3)+.×L)
[102] ZP[4;;]←(+/[1]P4)+.×L+.×⌹(I+(+/[1]P4)+.×L)
[103] ZP[5;;]←(+/[1]P5)+.×L+.×⌹(I+(+/[1]P5)+.×L)
[104] ESTIM3
[105] →0
```

La función **ESTIM3** calcula los estimadores de credibilidad para cada subcartera y para cada póliza, e invoca para su cálculo la función CREANP.

```
      ∇ESTIM3[⎕]∇
[0]   ESTIM3;NP;NP1;NPJ;⎕IO
[1]    ⎕IO←1
[2]    NP←((⍴K),1,2)⍴0
[3]    J←1
[4]   DIRNP:
[5]    NP[J;;]←(BEP[J;;]+.×ZP[J;;])+((⍳BET)+.×(I-ZP[J;;]))
[6]    →DIRNP×⍳(⍴K)≥J←J+1
[7]    NP1←K CREANP NP
[8]    NPJ←((+/K),1,2)⍴0
[9]    J←1
[10]  DIRNPJ:
[11]   NPJ[J;;]←(BEPJ[J;;]+.×ZPJ[J;;])+(NP1[J;;]+.×(I-ZPJ[J;;]))
[12]   →DIRNPJ×⍳(+/K)≥J←J+1
[13]   ' '
[14]  ⍝ RESULTADOS
[15]   RESSUNDT
```

La función **CREANP** crea una matriz columna en la cual se repite el estimador ajustado de credibilidad para cada subcartera tantas veces como pólizas tengan las subcarteras.

```
      ∇CREANP[⎕]∇
[0]   R←K CREANP NP;J;⎕IO;N;TK
[1]    ⎕IO←1
[2]    N←⍴K
[3]    R←((+/K),1,2)⍴0
[4]    TK←+\K
[5]    →(N=2)⍴DOS
[6]    →(N=3)⍴TRES
[7]    →(N=4)⍴CUATRO
[8]    →(N=5)⍴CINCO
[9]    →0
[10]  DOS:
[11]   J←1
[12]  DIR1:
[13]   R[J;;]←NP[1;;]
[14]   →DIR1×⍳(TK[1])≥J←J+1
[15]  DIR2:
[16]   R[J;;]←NP[2;;]
[17]   →DIR2×⍳(TK[2])≥J←J+1
[18]   →0
[19]  TRES:
[20]   J←1
[21]  DIR3:
[22]   R[J;;]←NP[1;;]
[23]   →DIR3×⍳(TK[1])≥J←J+1
[24]  DIR4:
[25]   R[J;;]←NP[2;;]
[26]   →DIR4×⍳(TK[2])≥J←J+1
[27]  DIR5:
[28]   R[J;;]←NP[3;;]
[29]   →DIR5×⍳(TK[3])≥J←J+1
[30]   →0
[31]  CUATRO:
[32]   J←1
[33]  DIR6:
[34]   R[J;;]←NP[1;;]
[35]   →DIR6×⍳(TK[1])≥J←J+1
[36]  DIR7:
[37]   R[J;;]←NP[2;;]
[38]   →DIR7×⍳(TK[2])≥J←J+1
```

```
[39] DIR8:
[40]  R[J;;]←NP[3;;]
[41]  →DIR8×⍳(TK[3])⍪J←J+1
[42] DIR9:
[43]  R[J;;]←NP[4;;]
[44]  →DIR9×⍳(TK[3])⍪J←J+1
[45]  →0
[46] CINCO:
[47]  J←1
[48] DIRA:
[49]  R[J;;]←NP[1;;]
[50]  →DIRA×⍳(TK[1])⍪J←J+1
[51] DIPB:
[52]  R[J;;]←NP[2;;]
[53]  →DIRB×⍳(TK[2])⍪J←J+1
[54] DIRC:
[55]  R[J;;]←NP[3;;]
[56]  →DIRC×⍳(TK[3])⍪J←J+1
[57] DIRD:
[58]  R[J;;]←NP[4;;]
[59]  →DIRD×⍳(TK[4])⍪J←J+1
[60] DIRE:
[61]  R[J;;]←NP[5;;]
[62]  →DIRE×⍳(TK[5])⍪J←J+1
[63]  →0
```

Las funciones **RESSUNDT** y **LAMBDA** proporcionan el formato de salida de los resultados de las funciones CALCSUNDT, ESTIM1, ESTIM2 y ESTIM3.

RESSUNDT:

```
      ∇RESSUNDT[⎕]∇
[0]  RESSUNDT;P;BLA;I;TOT;⎕IO
[1]   ⎕IO←1
[2]   P←⍴K
[3]   BLA←2 2⍴' '
[4]   'MODELO JERARQUICO DE SUNDT'
[5]   '**************************'
[6]   BLA
[7]   'NUMERO DE SUBCARTERAS CONSIDERADAS: ',⍕P
[8]   ' '
[9]   ' '
[10]  'NUMERO DE POLIZAS POR SUBCARTERA'
[11]  ' '
[12]  I←1
[13] DIR1:
[14]  'SUBCARTERA ',(⍕I),': ',⍕K[I]
[15]  →DIR1×⍳P⍪I←I+1
[16]  TOT←+/K
[17]  BLA
[18]  →(TM=1)⍴UNO
[19]  'Las matrices A y B son variables'
[20]  →SIGUE
[21] UNO:
[22]  'Las matrices A y B son constantes'
[23] SIGUE:
[24]  BLA
[25]  'ESTIMADORES INDIVIDUALES PARA CADA POLIZA'
[26]  '=========================================='
[27]  ' '
[28]  I←1
```

```
[29] DIR2:
[30]  'POLIZA ',⍕I
[31]  '------ '
[32]  ' '
[33]  '      PUNTO DE CORTE: ',⍕BEPJ[I;1;1]
[34]  '      PENDIENTE:      ',⍕BEPJ[I;1;2]
[35]  ' '
[36]  →DIR2×⍳TOT≥I←I+1
[37]  BLA
[38]  'ESTIMADORES AJUSTADOS DE CREDIBILIDAD PARA CADA POLIZA'
[39]  '=================================================='
[40]  ' '
[41]  I←1
[42] DIR3:
[43]  'POLIZA ',⍕I
[44]  '------ '
[45]  ' '
[46]  '      PUNTO DE CORTE: ',⍕NPJ[I;1;1]
[47]  '      PENDIENTE:      ',⍕NPJ[I;1;2]
[48]  ' '
[49]  →DIR3×⍳TOT≥I←I+1
[50]  BLA
[51]  'MATRICES DE CREDIBILIDAD PARA CADA POLIZA'
[52]  '=========================================='
[53]  ' '
[54]  I←1
[55] DIR4:
[56]  ' '
[57]  'POLIZA ',⍕I
[58]  '------ '
[59]  ' '
[60]  ZPJ[I;;]
[61]  ' '
[62]  →DIR4×⍳TOT≥I←I+1
[63]  BLA
[64]  'ESTIMADORES INDIVIDUALES PARA CADA SUBCARTERA'
[65]  '============================================='
[66]  ' '
[67]  I←1
[68] DIR5:
[69]  'SUBCARTERA ',⍕I
[70]  '----------'
[71]  ' '
[72]  '      PUNTO DE CORTE: ',⍕BEP[I;1;1]
[73]  '      PENDIENTE:      ',⍕BEP[I;1;2]
[74]  ' '
[75]  →DIR5×⍳P≥I←I+1
[76]  BLA
[77]  'ESTIMADORES AJUSTADOS DE CREDIBILIDAD PARA CADA SUBCARTERA'
[78]  '========================================================='
[79]  ' '
[80]  I←1
[81] DIR6:
[82]  'SUBCARTERA ',⍕I
[83]  '----------'
[84]  ' '
[85]  '      PUNTO DE CORTE: ',⍕NP[I;1;1]
[86]  '      PENDIENTE:      ',⍕NP[I;1;2]
[87]  ' '
[88]  →DIR6×⍳P≥I←I+1
[89]  BLA
[90]  'MATRICES DE CREDIBILIDAD PARA CADA SUBCARTERA'
[91]  '============================================='
[92]  ' '
```

```
[93]  I←1
[94] DIR7:
[95]  ' '
[96]  'SUBCARTERA ',⍕I
[97]  '----------'
[98]  ' '
[99]  ZP[I;;]
[100] ' '
[101] →DIR7×⍳P≥I←I+1
[102] BLA
[103] 'ESTIMADOR COLECTIVO'
[104] '==================='
[105] ' '
[106] '      PUNTO DE CORTE: ',⍕BET[1;1]
[107] '      PENDIENTE:      ',⍕BET[2;1]
[108] BLA
[109] 'VARIANZA ESPERADA         S2 = ',⍕S2
[110] BLA
[111] LAMBDA
```

LAMBDA:

```
      ∇LAMBDA[⎕]∇
[0]  LAMBDA;⎕IO
[1]   ⎕IO←1
[2]   'LAMBDA'
[3]   '------'
[4]   ' '
[5]   L
[6]   BLA
[7]   'LAMBDAp'
[8]   '-------'
[9]   ' '
[10]  LP
[11]  BLA
[12]  'Con:'
[13]  ' '
[14]  'G0 ='
[15]  ' '
[16]  G0
[17]  ' '
[18]  ' '
[19]  'G1 ='
[20]  ' '
[21]  G1
[22]  ' '
[23]  ' '
[24]  'G2 ='
[25]  ' '
[26]  G2
[27]  ' '
[28]  ' '
[29]  'H ='
[30]  ' '
[31]  H
[32]  BLA
[33]  →0
```