GAMS 30.3.0 rc5da09e Released Mar 6, 2020 WEX-WEI x86 64bit/MS Windows 04/05/20 16:46:49 Page 1
G e n e r a l A l g e b r a i c M o d e l i n g S y s t e m
C o m p i l a t i o n

```
  1  set j       set of years                          /year0*year10/;
  2  set jp(j)   set of years whos ends start a period /year0, year2, year5/;
  3  set p       set of processes                      /p1*p3/;
  4  set chem    set of chemicals                      /chem1*chem3/
  5
  6  parameter yr(j) year number
  7  / year0 0
  8    year1 1
  9    year2 2
 10    year3 3
 11    year4 4
 12    year5 5
 13    year6 6
 14    year7 7
 15    year8 8
 16    year9 9
 17    year10 10/;
 18
 19  parameter len(jp) the length of a period
 20  / year0 2
 21    year2 3
 22    year5 5 /;
 23
 24  parameter life(jp) the rest of the project life
 25  / year0 10
 26    year2 8
 27    year5 5 /;
 28
 29  Table alpha(jp,p) variable investment cost
 30            p1      p2      p3
 31    year0  1.38    2.72    1.76
 32    year2  1.56    3.22    2.34
 33    year5  1.78    4.60    2.84
 34  ;
 35  Table beta(jp,p) fixed investment cost
 36            p1      p2      p3
 37    year0  85      73      110
 38    year2  95      82      125
 39    year5  112     102     148
 40  ;
 41  Table opexf(j,p) operating expense factor
 42            p1      p2      p3
 43    year0  0.0     0.0     0.0
 44    year1  0.4     0.6     0.5
 45    year2  0.4     0.6     0.5
 46    year3  0.5     0.7     0.6
 47    year4  0.5     0.7     0.6
 48    year5  0.5     0.7     0.6
 49    year6  0.6     0.8     0.7
 50    year7  0.6     0.8     0.7
 51    year8  0.6     0.8     0.7
 52    year9  0.6     0.8     0.7
 53    year10 0.6     0.8     0.7
 54  ;
 55  Table prices(j, chem) chemical prices
 56            chem1   chem2   chem3
```

```
 57    year0  0       0       0
 58    year1  4       9.6     26.20
 59    year2  4       9.6     26.20
 60    year3  5.24    11.52   29.20
 61    year4  5.24    11.52   29.20
 62    year5  5.24    11.52   29.20
 63    year6  7.32    13.52   35.20
 64    year7  7.32    13.52   35.20
 65    year8  7.32    13.52   35.20
 66    year9  7.32    13.52   35.20
 67    year10 7.32    13.52   35.20
 68  ;
 69
 70  parameter i      intrest rate per year  /0.10/;
 71  parameter fsal   salvage value factor   /0.10/;
 72  parameter fwc    working capital factor /0.15/;
 73  parameter tax    tax rate               /0.45/;
 74  parameter fpv(j) present value factor;
 75
 76  * calculate present value factor
 77  loop(  j,  fpv(j) = 1.0/((1.0+i)**yr(j))   );
 78
 79
 80  binary variable   y(jp,p)      build process p in period jp or not;
 81  positive variable addCap(jp,p) additional capacity for process p in period
      jp;
 82  positive variable cap(j, p)    total capacity of p in year j;
 83  positive variable prflow(j,p)  product flows from process p in year j;
 84  positive variable inflow(j,p)  reactant flow into p in year j;
 85  positive variable pur1(j)      amount of chem 1 purchased year j;
 86  positive variable pur2(j)      amount of chem 2 purchased year j;
 87  positive variable sel3(j)      amount of chem 3 sold year j;
 88  positive variable inv(jp)      amount invested in jp;
 89  positive variable sell(j)      amount earned from the sale of chem3 in yea
     r j;
 90  positive variable opex(j)      operating expenses for year j;
 91  positive variable wc(jp)       working capital put in at begining of perio
     d jp;
 92  positive variable buy1(j)      amount spent to purchase chem1 in year j;
 93  positive variable buy2(j)      amount spent to purchace chem2 in year j;
 94  positive variable income(j)    taxable imcome year j;
 95  positive variable dep(j)       depriciation in year j;
 96  variable npv                   net present value;
 97
 98  * set upper bound on purchases and sales
 99  pur1.up(j) = 6$(yr(j) > yr('year0'))
100               + 1.5$(yr(j) > yr('year2'))
101               + 1.1$(yr(j) > yr('year5'));
102  pur2.up(j) = 20$(yr(j) > yr('year0'))
103               + 5.5$(yr(j) > yr('year2'))
104               + 4.5$(yr(j) > yr('year5'));
105  sel3.up(j) = 65$(yr(j) > yr('year0'))
106               + 10$(yr(j) > yr('year2'))
107               + 15$(yr(j) > yr('year5'));
108
109  * set upper bounds on investment amounts
110  inv.up('year0') = 200;
111  inv.up('year2') = 300;
112  inv.up('year5') = 400;
113
114  *
```

```
115  equations
116     mb_p1(j)        mass balance process 1
117     mb_p2(j)        mass balance process 2
118     mb_p3(j)        mass balance process 3
119     mb_p2p3(j)      mass balabce split between p2 and p3
120     addcaplim(jp,p) limit on additional capacity added in a period
121     p1cap(j)        eq for capacity of process 1 in year j
122     p2cap(j)        eq for capacity of process 2 in year j
123     p3cap(j)        eq for capacity of process 3 in year j
124
125
126
127     inveq(jp)       eq for amount of investment in period jp
128     npveq           eq for net present value
129     opexeq(j)       eq for operating expenses
130     wceq(jp)        eq for the amount of working capital put for period jp
131     sel3eq(j)       eq for the amount of chem 3 sold in year j
132     buy1eq(j)       eq for purchase costs of chem1 in year j
133     buy2eq(j)       eq for purchase costs of chem2 in year j
134     sell3eq(j)      eq for amount made from selling chem3
135     prlim(j,p)      eq for capacity limit on product flows
136     incomeeq(j)     eq for income in year j
137     depeq(j)        eq for depriciation in year j
138  ;
139
140
141  * Mass balances
142  mb_p1(j)  .. 1.11*prflow(j,'p1') =e= pur1(j);
143  mb_p2(j)  .. 1.22*prflow(j,'p2') =e= inflow(j,'p2');
144  mb_p3(j)  .. 1.05*prflow(j,'p3') =e= inflow(j,'p3');
145  mb_p2p3(j).. inflow(j,'p2') + inflow(j,'p3') =e= prflow(j,'p1') + pur2(j);
146
147  * Product capacity limits
148  prlim(j,p) .. prflow(j,p) =l= cap(j,p);
149  p1cap(j) .. cap(j,'p1') =e= sum(jp$(yr(j) > yr(jp)), addCap(jp,'p1'));
150  p2cap(j) .. cap(j,'p2') =e= sum(jp$(yr(j) > yr(jp)), addCap(jp,'p2'))
151                              + 50$(yr(j) > 0);
152  p3cap(j) .. cap(j,'p3') =e= sum(jp$(yr(j) > yr(jp)), addCap(jp,'p3'));
153
154  * Investments and working capital
155  addcaplim(jp,p) .. addCap(jp,p) =l= 100*y(jp,p);
156  inveq(jp).. inv(jp) =e= sum(p, beta(jp,p)*y(jp,p))
157                          + sum(p, alpha(jp,p)*addCap(jp,p));
158  wceq(jp) .. wc(jp)  =e= fwc*inv(jp);
159
160  * Buy and sell chemicals
161  sel3eq(j) .. sel3(j) =e= prflow(j,'p2')+prflow(j,'p3');
162  buy1eq(j) .. buy1(j) =e= pur1(j)*prices(j,'chem1');
163  buy2eq(j) .. buy2(j) =e= pur2(j)*prices(j,'chem2');
164  sell3eq(j).. sell(j) =e= sel3(j)*prices(j,'chem3');
165
166  * Income operating expences and depriciation
167  opexeq(j) .. opex(j) =e= sum(p, prflow(j,p)*opexf(j,p));
168  incomeeq(j) .. income(j) =e= sell(j) - opex(j)- buy1(j) - buy2(j);
169  depeq(j) .. dep(j) =e= sum(jp$(yr(j) > yr(jp)), (1.0-fsal)*inv(jp)/life(jp
     ) );
170
171  * Calculate NPV
172  npveq .. npv =e= sum(j, dep(j)*fpv(j))*tax
173                 + sum(j, income(j)*fpv(j))*(1-tax)
174                 - sum(jp, fpv(jp)*(inv(jp) + wc(jp)))
```

```
 175                   + fpv('year10')*sum(jp, wc(jp) + fsal*inv(jp));
 176
 177  * Make sure I get the best answer
 178  option optcr = 0;
 179
 180  * solve all equations maximize NPV
 181  model mod /all/;
 182  solve mod using mip maximizing npv;


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GAMS 30.3.0  rc5da09e Released Mar  6, 2020 WEX-WEI x86 64bit/MS Windows 04/05/20 16:46:49 Page 2
G e n e r a l   A l g e b r a i c   M o d e l i n g   S y s t e m
Equation Listing    SOLVE mod Using MIP From line 182


---- mb_p1  =E=  mass balance process 1

mb_p1(year0)..  1.11*prflow(year0,p1) - pur1(year0) =E= 0 ; (LHS = 0)

mb_p1(year1)..  1.11*prflow(year1,p1) - pur1(year1) =E= 0 ; (LHS = 0)

mb_p1(year2)..  1.11*prflow(year2,p1) - pur1(year2) =E= 0 ; (LHS = 0)

REMAINING 8 ENTRIES SKIPPED


---- mb_p2  =E=  mass balance process 2

mb_p2(year0)..  1.22*prflow(year0,p2) - inflow(year0,p2) =E= 0 ; (LHS = 0)

mb_p2(year1)..  1.22*prflow(year1,p2) - inflow(year1,p2) =E= 0 ; (LHS = 0)

mb_p2(year2)..  1.22*prflow(year2,p2) - inflow(year2,p2) =E= 0 ; (LHS = 0)

REMAINING 8 ENTRIES SKIPPED


---- mb_p3  =E=  mass balance process 3

mb_p3(year0)..  1.05*prflow(year0,p3) - inflow(year0,p3) =E= 0 ; (LHS = 0)

mb_p3(year1)..  1.05*prflow(year1,p3) - inflow(year1,p3) =E= 0 ; (LHS = 0)

mb_p3(year2)..  1.05*prflow(year2,p3) - inflow(year2,p3) =E= 0 ; (LHS = 0)

REMAINING 8 ENTRIES SKIPPED


---- mb_p2p3  =E=  mass balabce split between p2 and p3

mb_p2p3(year0)..  - prflow(year0,p1) + inflow(year0,p2) + inflow(year0,p3)

      - pur2(year0) =E= 0 ; (LHS = 0)

mb_p2p3(year1)..  - prflow(year1,p1) + inflow(year1,p2) + inflow(year1,p3)

      - pur2(year1) =E= 0 ; (LHS = 0)

mb_p2p3(year2)..  - prflow(year2,p1) + inflow(year2,p2) + inflow(year2,p3)
```

```
      - pur2(year2) =E= 0 ; (LHS = 0)
REMAINING 8 ENTRIES SKIPPED

---- addcaplim  =L=  limit on additional capacity added in a period
addcaplim(year0,p1)..  - 100*y(year0,p1) + addCap(year0,p1) =L= 0 ; (LHS = 0)
addcaplim(year0,p2)..  - 100*y(year0,p2) + addCap(year0,p2) =L= 0 ; (LHS = 0)
addcaplim(year0,p3)..  - 100*y(year0,p3) + addCap(year0,p3) =L= 0 ; (LHS = 0)
REMAINING 6 ENTRIES SKIPPED

---- p1cap  =E=  eq for capacity of process 1 in year j
p1cap(year0)..  cap(year0,p1) =E= 0 ; (LHS = 0)
p1cap(year1)..  - addCap(year0,p1) + cap(year1,p1) =E= 0 ; (LHS = 0)
p1cap(year2)..  - addCap(year0,p1) + cap(year2,p1) =E= 0 ; (LHS = 0)
REMAINING 8 ENTRIES SKIPPED

---- p2cap  =E=  eq for capacity of process 2 in year j
p2cap(year0)..  cap(year0,p2) =E= 0 ; (LHS = 0)
p2cap(year1)..  - addCap(year0,p2) + cap(year1,p2) =E= 50 ;
      (LHS = 0, INFES = 50 ****)
p2cap(year2)..  - addCap(year0,p2) + cap(year2,p2) =E= 50 ;
      (LHS = 0, INFES = 50 ****)
REMAINING 8 ENTRIES SKIPPED

---- p3cap  =E=  eq for capacity of process 3 in year j
p3cap(year0)..  cap(year0,p3) =E= 0 ; (LHS = 0)
p3cap(year1)..  - addCap(year0,p3) + cap(year1,p3) =E= 0 ; (LHS = 0)
p3cap(year2)..  - addCap(year0,p3) + cap(year2,p3) =E= 0 ; (LHS = 0)
REMAINING 8 ENTRIES SKIPPED

---- inveq  =E=  eq for amount of investment in period jp
inveq(year0)..  - 85*y(year0,p1) - 73*y(year0,p2) - 110*y(year0,p3)
      - 1.38*addCap(year0,p1) - 2.72*addCap(year0,p2) - 1.76*addCap(year0,p3)
      + inv(year0) =E= 0 ; (LHS = 0)
```

```
inveq(year2)..  - 95*y(year2,p1) - 82*y(year2,p2) - 125*y(year2,p3)
      - 1.56*addCap(year2,p1) - 3.22*addCap(year2,p2) - 2.34*addCap(year2,p3)
      + inv(year2) =E= 0 ; (LHS = 0)
inveq(year5)..  - 112*y(year5,p1) - 102*y(year5,p2) - 148*y(year5,p3)
      - 1.78*addCap(year5,p1) - 4.6*addCap(year5,p2) - 2.84*addCap(year5,p3)
      + inv(year5) =E= 0 ; (LHS = 0)

---- npveq  =E=  eq for net present value
npveq..  0.961445671057047*inv(year0) + 0.787891952048782*inv(year2)
      + 0.582366994116202*inv(year5) + 0.614456710570469*wc(year0)
      + 0.440902991562204*wc(year2) + 0.235378033629623*wc(year5)
      - 0.55*income(year0) - 0.5*income(year1) - 0.454545454545455*income(year2)
      - 0.413223140495868*income(year3) - 0.375657400450789*income(year4)
      - 0.341506727682535*income(year5) - 0.310460661529578*income(year6)
      - 0.282236965026889*income(year7) - 0.256579059115353*income(year8)
      - 0.233253690104867*income(year9) - 0.212048809186242*income(year10)
      - 0.45*dep(year0) - 0.409090909090909*dep(year1)
      - 0.371900826446281*dep(year2) - 0.33809166040571*dep(year3)
      - 0.307356054914282*dep(year4) - 0.27941459537662*dep(year5)
      - 0.2540132685242*dep(year6) - 0.230921153203818*dep(year7)
      - 0.20992832109438*dep(year8) - 0.190843928267618*dep(year9)
      - 0.173494480243289*dep(year10) + npv =E= 0 ; (LHS = 0)

---- opexeq  =E=  eq for operating expenses
opexeq(year0)..  opex(year0) =E= 0 ; (LHS = 0)
opexeq(year1)..  - 0.4*prflow(year1,p1) - 0.6*prflow(year1,p2)
      - 0.5*prflow(year1,p3) + opex(year1) =E= 0 ; (LHS = 0)
opexeq(year2)..  - 0.4*prflow(year2,p1) - 0.6*prflow(year2,p2)
      - 0.5*prflow(year2,p3) + opex(year2) =E= 0 ; (LHS = 0)
REMAINING 8 ENTRIES SKIPPED

---- wceq  =E=  eq for the amount of working capital put for period jp
```

```
wceq(year0)..  - 0.15*inv(year0) + wc(year0) =E= 0 ; (LHS = 0)

wceq(year2)..  - 0.15*inv(year2) + wc(year2) =E= 0 ; (LHS = 0)

wceq(year5)..  - 0.15*inv(year5) + wc(year5) =E= 0 ; (LHS = 0)

---- sel3eq  =E=  eq for the amount of chem 3 sold in year j

sel3eq(year0)..  - prflow(year0,p2) - prflow(year0,p3) + sel3(year0) =E= 0 ;
      (LHS = 0)

sel3eq(year1)..  - prflow(year1,p2) - prflow(year1,p3) + sel3(year1) =E= 0 ;
      (LHS = 0)

sel3eq(year2)..  - prflow(year2,p2) - prflow(year2,p3) + sel3(year2) =E= 0 ;
      (LHS = 0)

REMAINING 8 ENTRIES SKIPPED

---- buy1eq  =E=  eq for purchase costs of chem1 in year j

buy1eq(year0)..  buy1(year0) =E= 0 ; (LHS = 0)

buy1eq(year1)..  - 4*pur1(year1) + buy1(year1) =E= 0 ; (LHS = 0)

buy1eq(year2)..  - 4*pur1(year2) + buy1(year2) =E= 0 ; (LHS = 0)

REMAINING 8 ENTRIES SKIPPED

---- buy2eq  =E=  eq for purchase costs of chem2 in year j

buy2eq(year0)..  buy2(year0) =E= 0 ; (LHS = 0)

buy2eq(year1)..  - 9.6*pur2(year1) + buy2(year1) =E= 0 ; (LHS = 0)

buy2eq(year2)..  - 9.6*pur2(year2) + buy2(year2) =E= 0 ; (LHS = 0)

REMAINING 8 ENTRIES SKIPPED

---- sell3eq  =E=  eq for amount made from selling chem3

sell3eq(year0)..  sell(year0) =E= 0 ; (LHS = 0)

sell3eq(year1)..  - 26.2*sel3(year1) + sell(year1) =E= 0 ; (LHS = 0)

sell3eq(year2)..  - 26.2*sel3(year2) + sell(year2) =E= 0 ; (LHS = 0)

REMAINING 8 ENTRIES SKIPPED

---- prlim  =L=  eq for capacity limit on product flows

prlim(year0,p1)..  - cap(year0,p1) + prflow(year0,p1) =L= 0 ; (LHS = 0)
```

```
prlim(year0,p2)..  - cap(year0,p2) + prflow(year0,p2) =L= 0 ; (LHS = 0)

prlim(year0,p3)..  - cap(year0,p3) + prflow(year0,p3) =L= 0 ; (LHS = 0)

REMAINING 30 ENTRIES SKIPPED


---- incomeeq  =E=  eq for income in year j

incomeeq(year0)..  - sell(year0) + opex(year0) + buy1(year0) + buy2(year0)

      + income(year0) =E= 0 ; (LHS = 0)

incomeeq(year1)..  - sell(year1) + opex(year1) + buy1(year1) + buy2(year1)

      + income(year1) =E= 0 ; (LHS = 0)

incomeeq(year2)..  - sell(year2) + opex(year2) + buy1(year2) + buy2(year2)

      + income(year2) =E= 0 ; (LHS = 0)

REMAINING 8 ENTRIES SKIPPED


---- depeq  =E=  eq for depriciation in year j

depeq(year0)..  dep(year0) =E= 0 ; (LHS = 0)

depeq(year1)..  - 0.09*inv(year0) + dep(year1) =E= 0 ; (LHS = 0)

depeq(year2)..  - 0.09*inv(year0) + dep(year2) =E= 0 ; (LHS = 0)

REMAINING 8 ENTRIES SKIPPED

GAMS 30.3.0  rc5da09e Released Mar  6, 2020 WEX-WEI x86 64bit/MS Windows 04/05/20 16:46:49 Page 3
G e n e r a l   A l g e b r a i c   M o d e l i n g   S y s t e m
Column Listing      SOLVE mod Using MIP From line 182


---- y  build process p in period jp or not

y(year0,p1)
                (.LO, .L, .UP, .M = 0, 0, 1, 0)
     -100       addcaplim(year0,p1)
      -85       inveq(year0)

y(year0,p2)
                (.LO, .L, .UP, .M = 0, 0, 1, 0)
     -100       addcaplim(year0,p2)
      -73       inveq(year0)

y(year0,p3)
                (.LO, .L, .UP, .M = 0, 0, 1, 0)
     -100       addcaplim(year0,p3)
     -110       inveq(year0)

REMAINING 6 ENTRIES SKIPPED

---- addCap  additional capacity for process p in period jp

addCap(year0,p1)
```

```
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
         1      addcaplim(year0,p1)
        -1      p1cap(year1)
        -1      p1cap(year2)
        -1      p1cap(year3)
        -1      p1cap(year4)
        -1      p1cap(year5)
        -1      p1cap(year6)
        -1      p1cap(year7)
        -1      p1cap(year8)
        -1      p1cap(year9)
        -1      p1cap(year10)
        -1.38   inveq(year0)

addCap(year0,p2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
         1      addcaplim(year0,p2)
        -1      p2cap(year1)
        -1      p2cap(year2)
        -1      p2cap(year3)
        -1      p2cap(year4)
        -1      p2cap(year5)
        -1      p2cap(year6)
        -1      p2cap(year7)
        -1      p2cap(year8)
        -1      p2cap(year9)
        -1      p2cap(year10)
        -2.72   inveq(year0)

addCap(year0,p3)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
         1      addcaplim(year0,p3)
        -1      p3cap(year1)
        -1      p3cap(year2)
        -1      p3cap(year3)
        -1      p3cap(year4)
        -1      p3cap(year5)
        -1      p3cap(year6)
        -1      p3cap(year7)
        -1      p3cap(year8)
        -1      p3cap(year9)
        -1      p3cap(year10)
        -1.76   inveq(year0)

REMAINING 6 ENTRIES SKIPPED

---- cap  total capacity of p in year j

cap(year0,p1)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
         1      p1cap(year0)
        -1      prlim(year0,p1)

cap(year0,p2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
         1      p2cap(year0)
        -1      prlim(year0,p2)

cap(year0,p3)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
         1      p3cap(year0)
```

```
       -1       prlim(year0,p3)

REMAINING 30 ENTRIES SKIPPED

---- prflow  product flows from process p in year j

prflow(year0,p1)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1.11    mb_p1(year0)
       -1       mb_p2p3(year0)
        1       prlim(year0,p1)

prflow(year0,p2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1.22    mb_p2(year0)
       -1       sel3eq(year0)
        1       prlim(year0,p2)

prflow(year0,p3)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1.05    mb_p3(year0)
       -1       sel3eq(year0)
        1       prlim(year0,p3)

REMAINING 30 ENTRIES SKIPPED

---- inflow  reactant flow into p in year j

inflow(year0,p2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
       -1       mb_p2(year0)
        1       mb_p2p3(year0)

inflow(year0,p3)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
       -1       mb_p3(year0)
        1       mb_p2p3(year0)

inflow(year1,p2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
       -1       mb_p2(year1)
        1       mb_p2p3(year1)

REMAINING 19 ENTRIES SKIPPED

---- pur1  amount of chem 1 purchased year j

pur1(year0)
                (.LO, .L, .UP, .M = 0, 0, 0, 0)
       -1       mb_p1(year0)

pur1(year1)
                (.LO, .L, .UP, .M = 0, 0, 6, 0)
       -1       mb_p1(year1)
       -4       buy1eq(year1)

pur1(year2)
                (.LO, .L, .UP, .M = 0, 0, 6, 0)
       -1       mb_p1(year2)
       -4       buy1eq(year2)
```

```
REMAINING 8 ENTRIES SKIPPED

---- pur2  amount of chem 2 purchased year j

pur2(year0)
                (.LO, .L, .UP, .M = 0, 0, 0, 0)
       -1       mb_p2p3(year0)

pur2(year1)
                (.LO, .L, .UP, .M = 0, 0, 20, 0)
       -1       mb_p2p3(year1)
       -9.6     buy2eq(year1)

pur2(year2)
                (.LO, .L, .UP, .M = 0, 0, 20, 0)
       -1       mb_p2p3(year2)
       -9.6     buy2eq(year2)

REMAINING 8 ENTRIES SKIPPED

---- sel3  amount of chem 3 sold year j

sel3(year0)
                (.LO, .L, .UP, .M = 0, 0, 0, 0)
        1       sel3eq(year0)

sel3(year1)
                (.LO, .L, .UP, .M = 0, 0, 65, 0)
        1       sel3eq(year1)
      -26.2     sell3eq(year1)

sel3(year2)
                (.LO, .L, .UP, .M = 0, 0, 65, 0)
        1       sel3eq(year2)
      -26.2     sell3eq(year2)

REMAINING 8 ENTRIES SKIPPED

---- inv  amount invested in jp

inv(year0)
                (.LO, .L, .UP, .M = 0, 0, 200, 0)
        1       inveq(year0)
        0.9614  npveq
       -0.15    wceq(year0)
       -0.09    depeq(year1)
       -0.09    depeq(year2)
       -0.09    depeq(year3)
       -0.09    depeq(year4)
       -0.09    depeq(year5)
       -0.09    depeq(year6)
       -0.09    depeq(year7)
       -0.09    depeq(year8)
       -0.09    depeq(year9)
       -0.09    depeq(year10)

inv(year2)
                (.LO, .L, .UP, .M = 0, 0, 300, 0)
        1       inveq(year2)
        0.7879  npveq
       -0.15    wceq(year2)
```

```
       -0.1125  depeq(year3)
       -0.1125  depeq(year4)
       -0.1125  depeq(year5)
       -0.1125  depeq(year6)
       -0.1125  depeq(year7)
       -0.1125  depeq(year8)
       -0.1125  depeq(year9)
       -0.1125  depeq(year10)

inv(year5)
                (.LO, .L, .UP, .M = 0, 0, 400, 0)
        1       inveq(year5)
        0.5824  npveq
       -0.15    wceq(year5)
       -0.18    depeq(year6)
       -0.18    depeq(year7)
       -0.18    depeq(year8)
       -0.18    depeq(year9)
       -0.18    depeq(year10)


---- sell  amount earned from the sale of chem3 in year j

sell(year0)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       sell3eq(year0)
       -1       incomeeq(year0)

sell(year1)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       sell3eq(year1)
       -1       incomeeq(year1)

sell(year2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       sell3eq(year2)
       -1       incomeeq(year2)

REMAINING 8 ENTRIES SKIPPED

---- opex  operating expenses for year j

opex(year0)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       opexeq(year0)
        1       incomeeq(year0)

opex(year1)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       opexeq(year1)
        1       incomeeq(year1)

opex(year2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       opexeq(year2)
        1       incomeeq(year2)

REMAINING 8 ENTRIES SKIPPED

---- wc  working capital put in at begining of period jp
```

```
wc(year0)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        0.6145  npveq
        1       wceq(year0)

wc(year2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        0.4409  npveq
        1       wceq(year2)

wc(year5)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        0.2354  npveq
        1       wceq(year5)


---- buy1  amount spent to purchase chem1 in year j

buy1(year0)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       buy1eq(year0)
        1       incomeeq(year0)

buy1(year1)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       buy1eq(year1)
        1       incomeeq(year1)

buy1(year2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       buy1eq(year2)
        1       incomeeq(year2)

REMAINING 8 ENTRIES SKIPPED

---- buy2  amount spent to purchace chem2 in year j

buy2(year0)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       buy2eq(year0)
        1       incomeeq(year0)

buy2(year1)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       buy2eq(year1)
        1       incomeeq(year1)

buy2(year2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
        1       buy2eq(year2)
        1       incomeeq(year2)

REMAINING 8 ENTRIES SKIPPED

---- income  taxable imcome year j

income(year0)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
       -0.55    npveq
        1       incomeeq(year0)
```

```
income(year1)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
       -0.5     npveq
        1       incomeeq(year1)

income(year2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
       -0.4545  npveq
        1       incomeeq(year2)

REMAINING 8 ENTRIES SKIPPED

---- dep  depriciation in year j

dep(year0)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
       -0.45    npveq
        1       depeq(year0)

dep(year1)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
       -0.4091  npveq
        1       depeq(year1)

dep(year2)
                (.LO, .L, .UP, .M = 0, 0, +INF, 0)
       -0.3719  npveq
        1       depeq(year2)

REMAINING 8 ENTRIES SKIPPED

---- npv  net present value

npv
                (.LO, .L, .UP, .M = -INF, 0, +INF, 0)
        1       npveq

GAMS 30.3.0  rc5da09e Released Mar  6, 2020 WEX-WEI x86 64bit/MS Windows 04/05/20 16:46:49 Page 4
G e n e r a l   A l g e b r a i c   M o d e l i n g   S y s t e m
Model Statistics    SOLVE mod Using MIP From line 182


MODEL STATISTICS

BLOCKS OF EQUATIONS          19     SINGLE EQUATIONS          203
BLOCKS OF VARIABLES          17     SINGLE VARIABLES          212
NON ZERO ELEMENTS           578     DISCRETE VARIABLES          9


GENERATION TIME      =        0.015 SECONDS      4 MB  30.3.0 rc5da09e WEX-WEI


EXECUTION TIME       =        0.046 SECONDS      4 MB  30.3.0 rc5da09e WEX-WEI
GAMS 30.3.0  rc5da09e Released Mar  6, 2020 WEX-WEI x86 64bit/MS Windows 04/05/20 16:46:49 Page 5
G e n e r a l   A l g e b r a i c   M o d e l i n g   S y s t e m
Solution Report     SOLVE mod Using MIP From line 182


               S O L V E      S U M M A R Y

     MODEL   mod                 OBJECTIVE  npv
```

```
     TYPE    MIP                 DIRECTION  MAXIMIZE
     SOLVER  CPLEX               FROM LINE  182

**** SOLVER STATUS     1 Normal Completion
**** MODEL STATUS      1 Optimal
**** OBJECTIVE VALUE             1697.6072

 RESOURCE USAGE, LIMIT          0.110      1000.000
 ITERATION COUNT, LIMIT       106    2000000000

IBM ILOG CPLEX   30.3.0 rc5da09e Released Mar 06, 2020 WEI x86 64bit/MS Window
*** This solver runs with a demo license. No commercial use.
Cplex 12.10.0.0

Space for names approximately 0.01 Mb
Use option 'names no' to turn use of names off
MIP status(101): integer optimal solution
Cplex Time: 0.08sec (det. 3.09 ticks)
Fixing integer variables, and solving final LP...
Fixed MIP status(1): optimal
Cplex Time: 0.00sec (det. 0.33 ticks)
Proven optimal solution.

MIP Solution:         1697.607221    (78 iterations, 0 nodes)
Final Solve:          1697.607221    (28 iterations)

Best possible:        1697.607221
Absolute gap:            0.000000
Relative gap:            0.000000


---- EQU mb_p1  mass balance process 1

          LOWER     LEVEL     UPPER    MARGINAL

year0       .         .         .          .
year1       .         .         .        9.272
year2       .         .         .        8.429
year3       .         .         .        9.954
year4       .         .         .        9.049
year5       .         .         .        8.226
year6       .         .         .        6.755
year7       .         .         .        8.202
year8       .         .         .        7.456
year9       .         .         .        6.778
year10      .         .         .        6.162

---- EQU mb_p2  mass balance process 2

          LOWER     LEVEL     UPPER    MARGINAL

year0       .         .         .          .
year1       .         .         .       10.492
year2       .         .         .        9.538
year3       .         .         .       11.255
year4       .         .         .       10.232
year5       .         .         .        9.302
year6       .         .         .        8.795
year7       .         .         .        9.274
year8       .         .         .        8.430
year9       .         .         .        7.664
```

year10 . . . 6.967

---- EQU mb_p3 mass balance process 3

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	.
year1	.	.	.	.
year2	.	.	.	.
year3	.	.	.	11.255
year4	.	.	.	10.232
year5	.	.	.	9.302
year6	.	.	.	8.795
year7	.	.	.	9.274
year8	.	.	.	8.430
year9	.	.	.	7.664
year10	.	.	.	6.967

---- EQU mb_p2p3 mass balabce split between p2 and p3

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	.
year1	.	.	.	10.492
year2	.	.	.	9.538
year3	.	.	.	11.255
year4	.	.	.	10.232
year5	.	.	.	9.302
year6	.	.	.	8.795
year7	.	.	.	9.274
year8	.	.	.	8.430
year9	.	.	.	7.664
year10	.	.	.	6.967

---- EQU addcaplim limit on additional capacity added in a period

	LOWER	LEVEL	UPPER	MARGINAL
year0.p1	-INF	-92.252	.	.
year0.p2	-INF	.	.	.
year0.p3	-INF	.	.	24.592
year2.p1	-INF	.	.	0.126
year2.p2	-INF	.	.	.
year2.p3	-INF	-64.050	.	.
year5.p1	-INF	.	.	1.111
year5.p2	-INF	.	.	.
year5.p3	-INF	.	.	1.476

---- EQU p1cap eq for capacity of process 1 in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	.
year1	.	.	.	EPS
year2	.	.	.	EPS
year3	.	.	.	EPS
year4	.	.	.	EPS
year5	.	.	.	EPS
year6	.	.	.	1.111
year7	.	.	.	EPS
year8	.	.	.	EPS

```
year9       .          .          .          EPS
year10      .          .          .          EPS

---- EQU p2cap  eq for capacity of process 2 in year j

          LOWER     LEVEL     UPPER    MARGINAL

year0       .         .         .          .
year1     50.000    50.000    50.000       EPS
year2     50.000    50.000    50.000       EPS
year3     50.000    50.000    50.000       EPS
year4     50.000    50.000    50.000       EPS
year5     50.000    50.000    50.000       EPS
year6     50.000    50.000    50.000       EPS
year7     50.000    50.000    50.000       EPS
year8     50.000    50.000    50.000       EPS
year9     50.000    50.000    50.000       EPS
year10    50.000    50.000    50.000       EPS

---- EQU p3cap  eq for capacity of process 3 in year j

          LOWER     LEVEL     UPPER    MARGINAL

year0       .         .         .          .
year1       .         .         .       12.850
year2       .         .         .       11.682
year3       .         .         .          EPS
year4       .         .         .          EPS
year5       .         .         .          EPS
year6       .         .         .        1.476
year7       .         .         .          EPS
year8       .         .         .          EPS
year9       .         .         .          EPS
year10      .         .         .          EPS

---- EQU inveq  eq for amount of investment in period jp

         LOWER     LEVEL     UPPER    MARGINAL

year0      .         .         .       -0.805
year2      .         .         .       -0.631
year5      .         .         .          .

                     LOWER     LEVEL     UPPER    MARGINAL

---- EQU npveq           .         .         .        1.000

  npveq  eq for net present value

---- EQU opexeq  eq for operating expenses

          LOWER     LEVEL     UPPER    MARGINAL

year0       .         .         .          .
year1       .         .         .       -0.500
year2       .         .         .       -0.455
year3       .         .         .       -0.413
year4       .         .         .       -0.376
year5       .         .         .       -0.342
year6       .         .         .       -0.310
year7       .         .         .       -0.282
```

year8	.	.	.	-0.257
year9	.	.	.	-0.233
year10	.	.	.	-0.212

---- EQU wceq eq for the amount of working capital put for period jp

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	-0.614
year2	.	.	.	-0.441
year5	.	.	.	.

---- EQU sel3eq eq for the amount of chem 3 sold in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	.
year1	.	.	.	13.100
year2	.	.	.	11.909
year3	.	.	.	12.066
year4	.	.	.	10.969
year5	.	.	.	9.972
year6	.	.	.	10.928
year7	.	.	.	9.935
year8	.	.	.	9.032
year9	.	.	.	8.211
year10	.	.	.	7.464

---- EQU buy1eq eq for purchase costs of chem1 in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	.
year1	.	.	.	-0.500
year2	.	.	.	-0.455
year3	.	.	.	-0.413
year4	.	.	.	-0.376
year5	.	.	.	-0.342
year6	.	.	.	-0.310
year7	.	.	.	-0.282
year8	.	.	.	-0.257
year9	.	.	.	-0.233
year10	.	.	.	-0.212

---- EQU buy2eq eq for purchase costs of chem2 in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	.
year1	.	.	.	-0.500
year2	.	.	.	-0.455
year3	.	.	.	-0.413
year4	.	.	.	-0.376
year5	.	.	.	-0.342
year6	.	.	.	-0.310
year7	.	.	.	-0.282
year8	.	.	.	-0.257
year9	.	.	.	-0.233
year10	.	.	.	-0.212

---- EQU sell3eq eq for amount made from selling chem3

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	0.550
year1	.	.	.	0.500
year2	.	.	.	0.455
year3	.	.	.	0.413
year4	.	.	.	0.376
year5	.	.	.	0.342
year6	.	.	.	0.310
year7	.	.	.	0.282
year8	.	.	.	0.257
year9	.	.	.	0.233
year10	.	.	.	0.212

---- EQU prlim eq for capacity limit on product flows

	LOWER	LEVEL	UPPER	MARGINAL
year0 .p1	-INF	.	.	.
year0 .p2	-INF	.	.	.
year0 .p3	-INF	.	.	.
year1 .p1	-INF	-2.342	.	.
year1 .p2	-INF	-29.176	.	.
year1 .p3	-INF	.	.	12.850
year2 .p1	-INF	-2.342	.	.
year2 .p2	-INF	-29.176	.	.
year2 .p3	-INF	.	.	11.682
year3 .p1	-INF	-0.991	.	.
year3 .p2	-INF	-50.000	.	.
year3 .p3	-INF	-5.230	.	.
year4 .p1	-INF	-0.991	.	.
year4 .p2	-INF	-50.000	.	.
year4 .p3	-INF	-5.230	.	.
year5 .p1	-INF	-0.991	.	.
year5 .p2	-INF	-50.000	.	.
year5 .p3	-INF	-5.230	.	.
year6 .p1	-INF	.	.	1.111
year6 .p2	-INF	-50.000	.	.
year6 .p3	-INF	.	.	1.476
year7 .p1	-INF	.	.	.
year7 .p2	-INF	-50.000	.	.
year7 .p3	-INF	.	.	.
year8 .p1	-INF	.	.	.
year8 .p2	-INF	-50.000	.	.
year8 .p3	-INF	.	.	.
year9 .p1	-INF	.	.	.
year9 .p2	-INF	-50.000	.	.
year9 .p3	-INF	.	.	.
year10.p1	-INF	.	.	.
year10.p2	-INF	-50.000	.	.
year10.p3	-INF	.	.	.

---- EQU incomeeq eq for income in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	0.550
year1	.	.	.	0.500
year2	.	.	.	0.455
year3	.	.	.	0.413

```
year4       .          .          .         0.376
year5       .          .          .         0.342
year6       .          .          .         0.310
year7       .          .          .         0.282
year8       .          .          .         0.257
year9       .          .          .         0.233
year10      .          .          .         0.212

---- EQU depeq  eq for depriciation in year j

          LOWER      LEVEL      UPPER    MARGINAL

year0       .          .          .         0.450
year1       .          .          .         0.409
year2       .          .          .         0.372
year3       .          .          .         0.338
year4       .          .          .         0.307
year5       .          .          .         0.279
year6       .          .          .         0.254
year7       .          .          .         0.231
year8       .          .          .         0.210
year9       .          .          .         0.191
year10      .          .          .         0.173

---- VAR y  build process p in period jp or not

            LOWER      LEVEL      UPPER    MARGINAL

year0.p1      .          1.000      1.000   -68.405
year0.p2      .            .        1.000   -58.747
year0.p3      .            .        1.000  2370.633
year2.p1      .            .        1.000   -47.279
year2.p2      .            .        1.000   -51.727
year2.p3      .          1.000      1.000   -78.853
year5.p1      .            .        1.000   111.057
year5.p2      .            .        1.000       EPS
year5.p3      .            .        1.000   147.612

---- VAR addCap  additional capacity for process p in period jp

            LOWER      LEVEL      UPPER    MARGINAL

year0.p1      .          7.748      +INF         .
year0.p2      .            .        +INF      -2.189
year0.p3      .            .        +INF         .
year2.p1      .            .        +INF         .
year2.p2      .            .        +INF      -2.031
year2.p3      .         35.950      +INF         .
year5.p1      .            .        +INF         .
year5.p2      .            .        +INF       EPS
year5.p3      .            .        +INF         .

---- VAR cap  total capacity of p in year j

             LOWER      LEVEL      UPPER    MARGINAL

year0 .p1     .            .         +INF       EPS
year0 .p2     .            .         +INF       EPS
year0 .p3     .            .         +INF       EPS
year1 .p1     .          7.748       +INF         .
year1 .p2     .         50.000       +INF         .
```

year1 .p3	.	.	+INF	.
year2 .p1	.	7.748	+INF	.
year2 .p2	.	50.000	+INF	.
year2 .p3	.	.	+INF	.
year3 .p1	.	7.748	+INF	.
year3 .p2	.	50.000	+INF	.
year3 .p3	.	35.950	+INF	.
year4 .p1	.	7.748	+INF	.
year4 .p2	.	50.000	+INF	.
year4 .p3	.	35.950	+INF	.
year5 .p1	.	7.748	+INF	.
year5 .p2	.	50.000	+INF	.
year5 .p3	.	35.950	+INF	.
year6 .p1	.	7.748	+INF	.
year6 .p2	.	50.000	+INF	.
year6 .p3	.	35.950	+INF	.
year7 .p1	.	7.748	+INF	.
year7 .p2	.	50.000	+INF	.
year7 .p3	.	35.950	+INF	.
year8 .p1	.	7.748	+INF	.
year8 .p2	.	50.000	+INF	.
year8 .p3	.	35.950	+INF	.
year9 .p1	.	7.748	+INF	.
year9 .p2	.	50.000	+INF	.
year9 .p3	.	35.950	+INF	.
year10.p1	.	7.748	+INF	.
year10.p2	.	50.000	+INF	.
year10.p3	.	35.950	+INF	.

---- VAR prflow product flows from process p in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0 .p1	.	.	+INF	EPS
year0 .p2	.	.	+INF	EPS
year0 .p3	.	.	+INF	EPS
year1 .p1	.	5.405	+INF	.
year1 .p2	.	20.824	+INF	.
year1 .p3	.	.	+INF	.
year2 .p1	.	5.405	+INF	.
year2 .p2	.	20.824	+INF	.
year2 .p3	.	.	+INF	.
year3 .p1	.	6.757	+INF	.
year3 .p2	.	.	+INF	-1.955
year3 .p3	.	30.721	+INF	.
year4 .p1	.	6.757	+INF	.
year4 .p2	.	.	+INF	-1.777
year4 .p3	.	30.721	+INF	.
year5 .p1	.	6.757	+INF	.
year5 .p2	.	.	+INF	-1.615
year5 .p3	.	30.721	+INF	.
year6 .p1	.	7.748	+INF	.
year6 .p2	.	.	+INF	-0.050
year6 .p3	.	35.950	+INF	.
year7 .p1	.	7.748	+INF	.
year7 .p2	.	.	+INF	-1.605
year7 .p3	.	35.950	+INF	.
year8 .p1	.	7.748	+INF	.
year8 .p2	.	.	+INF	-1.459
year8 .p3	.	35.950	+INF	.
year9 .p1	.	7.748	+INF	.

year9 .p2	.	.	+INF	-1.326
year9 .p3	.	35.950	+INF	.
year10.p1	.	7.748	+INF	.
year10.p2	.	.	+INF	-1.206
year10.p3	.	35.950	+INF	.

---- VAR inflow reactant flow into p in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0 .p2	.	.	+INF	EPS
year0 .p3	.	.	+INF	EPS
year1 .p2	.	25.405	+INF	.
year1 .p3	.	.	+INF	-10.492
year2 .p2	.	25.405	+INF	.
year2 .p3	.	.	+INF	-9.538
year3 .p2	.	.	+INF	.
year3 .p3	.	32.257	+INF	.
year4 .p2	.	.	+INF	.
year4 .p3	.	32.257	+INF	.
year5 .p2	.	.	+INF	.
year5 .p3	.	32.257	+INF	.
year6 .p2	.	.	+INF	.
year6 .p3	.	37.748	+INF	.
year7 .p2	.	.	+INF	.
year7 .p3	.	37.748	+INF	.
year8 .p2	.	.	+INF	.
year8 .p3	.	37.748	+INF	.
year9 .p2	.	.	+INF	.
year9 .p3	.	37.748	+INF	.
year10.p2	.	.	+INF	.
year10.p3	.	37.748	+INF	.

---- VAR pur1 amount of chem 1 purchased year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	EPS
year1	.	6.000	6.000	7.272
year2	.	6.000	6.000	6.611
year3	.	7.500	7.500	7.789
year4	.	7.500	7.500	7.081
year5	.	7.500	7.500	6.437
year6	.	8.600	8.600	4.483
year7	.	8.600	8.600	6.136
year8	.	8.600	8.600	5.578
year9	.	8.600	8.600	5.071
year10	.	8.600	8.600	4.610

---- VAR pur2 amount of chem 2 purchased year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	EPS
year1	.	20.000	20.000	5.692
year2	.	20.000	20.000	5.174
year3	.	25.500	25.500	6.495
year4	.	25.500	25.500	5.905
year5	.	25.500	25.500	5.368
year6	.	30.000	30.000	4.598
year7	.	30.000	30.000	5.458

year8	.	30.000	30.000	4.962
year9	.	30.000	30.000	4.510
year10	.	30.000	30.000	4.100

---- VAR sel3 amount of chem 3 sold year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	.	EPS
year1	.	20.824	65.000	.
year2	.	20.824	65.000	.
year3	.	30.721	75.000	.
year4	.	30.721	75.000	.
year5	.	30.721	75.000	.
year6	.	35.950	90.000	.
year7	.	35.950	90.000	.
year8	.	35.950	90.000	.
year9	.	35.950	90.000	.
year10	.	35.950	90.000	.

---- VAR inv amount invested in jp

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	95.692	200.000	.
year2	.	209.124	300.000	.
year5	.	.	400.000	-0.392

---- VAR sell amount earned from the sale of chem3 in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	+INF	.
year1	.	545.591	+INF	.
year2	.	545.591	+INF	.
year3	.	897.045	+INF	.
year4	.	897.045	+INF	.
year5	.	897.045	+INF	.
year6	.	1265.448	+INF	.
year7	.	1265.448	+INF	.
year8	.	1265.448	+INF	.
year9	.	1265.448	+INF	.
year10	.	1265.448	+INF	.

---- VAR opex operating expenses for year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	+INF	-0.550
year1	.	14.657	+INF	.
year2	.	14.657	+INF	.
year3	.	21.811	+INF	.
year4	.	21.811	+INF	.
year5	.	21.811	+INF	.
year6	.	29.814	+INF	.
year7	.	29.814	+INF	.
year8	.	29.814	+INF	.
year9	.	29.814	+INF	.
year10	.	29.814	+INF	.

---- VAR wc working capital put in at begining of period jp

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	14.354	+INF	.
year2	.	31.369	+INF	.
year5	.	.	+INF	-0.235

---- VAR buy1 amount spent to purchase chem1 in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	+INF	-0.550
year1	.	24.000	+INF	.
year2	.	24.000	+INF	.
year3	.	39.300	+INF	.
year4	.	39.300	+INF	.
year5	.	39.300	+INF	.
year6	.	62.952	+INF	.
year7	.	62.952	+INF	.
year8	.	62.952	+INF	.
year9	.	62.952	+INF	.
year10	.	62.952	+INF	.

---- VAR buy2 amount spent to purchace chem2 in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	+INF	-0.550
year1	.	192.000	+INF	.
year2	.	192.000	+INF	.
year3	.	293.760	+INF	.
year4	.	293.760	+INF	.
year5	.	293.760	+INF	.
year6	.	405.600	+INF	.
year7	.	405.600	+INF	.
year8	.	405.600	+INF	.
year9	.	405.600	+INF	.
year10	.	405.600	+INF	.

---- VAR income taxable imcome year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	+INF	.
year1	.	314.935	+INF	.
year2	.	314.935	+INF	.
year3	.	542.174	+INF	.
year4	.	542.174	+INF	.
year5	.	542.174	+INF	.
year6	.	767.082	+INF	.
year7	.	767.082	+INF	.
year8	.	767.082	+INF	.
year9	.	767.082	+INF	.
year10	.	767.082	+INF	.

---- VAR dep depriciation in year j

	LOWER	LEVEL	UPPER	MARGINAL
year0	.	.	+INF	.
year1	.	8.612	+INF	.

```
year2       .         8.612     +INF       .
year3       .        32.139     +INF       .
year4       .        32.139     +INF       .
year5       .        32.139     +INF       .
year6       .        32.139     +INF       .
year7       .        32.139     +INF       .
year8       .        32.139     +INF       .
year9       .        32.139     +INF       .
year10      .        32.139     +INF       .

                       LOWER     LEVEL     UPPER    MARGINAL

---- VAR npv            -INF   1697.607     +INF       .

  npv  net present value


**** REPORT SUMMARY :        0     NONOPT
                             0 INFEASIBLE
                             0  UNBOUNDED


EXECUTION TIME       =        0.000 SECONDS      2 MB  30.3.0 rc5da09e WEX-WEI


USER: GAMS Demo license for Yang Song                G200402|0002CO-GEN
      Samsung TSDI, China                                        DL006057


**** FILE SUMMARY

Input      F:\Thinkpad transfer\CMU Study\Rescued CMU course materials\06665 Pro
           cess Systems Modeling\A Mixed Integer Programming Project\prob2hw2.gm
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Output     C:\Users\admin\Documents\gamsdir\projdir\prob2hw2.lst
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