Matlab Code for the Case Study in Chapter 7

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%*************************************
%solve problem for 9 scenarios
%*************************************
% Variables for Robust Optimisation model
t1 = clock;
time1 = etime(clock,t1);

global landa;
global omega;
global p;
global t;
global pl;
global cc;
global toc;
global y0;
global alphacut;

y0=[90 130 80 90 70 80 90 70 75 70 70 80 75 70 80 70 70 80 75 70 80 90 13 14 13 13 14 13 13 14 13];
p=[0.14 0.097 0.1297 0.1525 0.094 0.141 0.091 0.065 0.09];%probability for each scenario
%it is defined by alpha cut from ANFIS
a=[8 11.7 5 4 6.0 8.7 4 5 0.14
  8 10.7 5 4 6.0 8.3 4 5 0.14
  8 10 5 4 6.0 8 4 5 0.14
  8 9.6 5 4 6.0 7.8 4 5 0.14
  8 9.3 5 4 6.0 7.5 4 5 0.14
  8 11.7 5 4 6.0 10 4 5 0.097
  8 10.7 5 4 6.3 9.7 4 5 0.097
  8 10 5 4 7.0 9.0 4 5 0.097
  8 9.6 5 4 7.4 8.6 4 5 0.097
  8 9.3 5 4 7.7 8.3 4 5 0.097
  8 11.7 5 4 6.5 10 4 5 0.1297
  8 10.7 5 4 7.3 10 4 5 0.1297
  8 10 5 4 8 10 4 5 0.1297
  8 9.6 5 4 8.4 10 4 5 0.1297
  8 9.3 5 4 8.7 10 4 5 0.1297%first
  8 12 5 4 6.0 8.7 4 5 0.1525
  8.3 11.7 5 4 6.0 8.3 4 5 0.1525
  9 11 5 4 6.0 8 4 5 0.1525
  9.4 10.6 5 4 6.0 7.8 4 5 0.1525
  9.7 10.3 5 4 6.0 7.5 4 5 0.1525
  8 12 5 4 6.0 10 4 5 0.094
  8.3 11.7 5 4 6.3 9.7 4 5 0.094
  9 11 5 4 7.0 9.0 4 5 0.094
  9.4 10.6 5 4 7.4 8.6 4 5 0.094
  9.7 10.3 5 4 7.7 8.3 4 5 0.094
  8 12 5 4 6.5 10 4 5 0.141
  8.3 11.7 5 4 7.3 10 4 5 0.141
  9 11 5 4 8 10 4 5 0.141
  9.4 10.6 5 4 8.4 10 4 5 0.141
  9.7 10.3 5 4 8.7 10 4 5 0.141%second
  8 12 5 4 6.0 8.7 4 5 0.091
  9.3 12 5 4 6.0 8.3 4 5 0.091
  10 12 5 4 6.0 8 4 5 0.091
  10.4 12 5 4 6.0 7.8 4 5 0.091
  10.7 12 5 4 6.0 7.5 4 5 0.091
  8 12 5 4 6.0 10 4 5 0.065
  9.3 12 5 4 6.3 9.7 4 5 0.065
  10 12 5 4 7.0 9.0 4 5 0.065
  10.4 12 5 4 7.4 8.6 4 5 0.065
  10.7 12 5 4 7.7 8.3 4 5 0.065
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  8 12 5 4 6.5 10 4 5 0.09
  9.3 12 5 4 7.3 10 4 5 0.09
  10 12 5 4 8 10 4 5 0.09
  10.4 12 5 4 8.4 10 4 5 0.09
  10.7 12 5 4 8.7 10 4 5 0.09%third
  ]

%*************************************
%optimise first stage model based on different alpha cut
for k=1:45
ff(k)=lp(a(k,1),a(k,2),a(k,3),a(k,4),a(k,5),a(k,6),a(k,7),a(k,8),a(k,9));
end;
%*************************************
%finding the best answer for each scenario (different alpha cut(5 alpha cuts))
k=0;
alphacut=zeros(1,45);
for j=1:5:45
k=1+k;
alphacut(k)=max(ff(j:j+4));
end;
%*************************************
k=1;
for i=1:45
  if ff(i)==alphacut(k)
     t(k)=a(i,6);
     pl(k)=a(i,2);
     k=k+1;
  end
end;

%************************
cc=[4 5];% fixed cost for each resource
toc=[4 3 3 4 3 3 4 3 3
    5 4 4 5 4 4 5 4 4];% operation cost for each resource and scenario
x=zeros(31,1);
excess=zeros(10,10);
landa=0;
for tt=1:5
   ff=0;
   omega=200;
for l=1:5
%*************************************
% making Aeq matrix
A=zeros(11,31);
for i=1:2 %2 is the number of resources
 A(i,i)=-1;
 c=1;
 A(i,c+2)=1;
 A(i,c+3)=1;
 A(i,c+4)=1;
 A(i,c+5)=1;
 A(i,c+6)=1;
 A(i,c+7)=1;
 A(i,c+8)=1;
 A(i,c+9)=1;
 A(i,c+10)=1;
 c=c+9;
 A(i,2+2*9+i)=1;
end
sc=1;%for scenarios in loop
for i=3:11 %2 is the number of resources so start from 3
 A(i,i-2+2)=-(t(sc));
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 A(i,i-2+2+9)=-(t(sc));
 A(i,2*9+2+sc)=-1;%5 number of variables + 2 number of resources
 sc=sc+1;
end


for i=1:2 % number of resources (2)
b(i)=0;
end

for i=3:11 % number of resources (2)+1
b(i)=-t(i-2)*pl(i-2);
end

%*********************************
y0=y0-(y0*0.02);
y0(1)=y0(1)+(y0(1)*0.08);
y0(2)=y0(2)+(y0(2)*0.08);

lb =zeros(31,1);
% Start with the default options
options = optimset;
% Modify options setting
options = optimset(options,'LargeScale' ,'on');
y=fmincon(@objfunc9,y0,A,b,[],[],lb,[],[],options);
%**********************************
%**********find solution for each scenario
for k=1:9
    for i=1:2
        ff(k,l)= cc(i)*y(i);
    end
end

for k=1:9
    k1=k+2;
    for i=1:2
        ff(k,l)= t(k)*toc(i,k)*y(k1)+ff(k,l);
        k1=k1+9;
    end
end
k1=2+2+9*2;
for sc=1:9%(2+3 -1)
%now calculate the excess capacity
   excess(tt,l)=y(k1)+excess(tt,l);
   k1=k1+1;
end
omega=omega+200;
end
% changing to megawatt
ff=ff;
%defining mean , varience and excess capacity
ave=mean(ff,1);
stdev=std(ff,0,1);

for i=1:5
    avet(tt,i)=ave(1,i)*1000;
    stedvt(tt,i)=stdev(1,i);
end
landa=landa+0.02;
end

t2 = clock;
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time2 = etime(clock,t2);
totaltime=time2-time1;


function f = objfunc9(x)
%*************************************
global p;
global t;
global pl;
global cc;
global toc;
global alphacut;
global landa;
global omega;
global y0;
y=y0;
sc=1;
for i=1:2
   for sc=1:9
   f2 = p(sc)*cc(i)*y(i);
   end
end
k1=2;% 2 is the number of resources
for i=1:2% 2 is the number of resources and 3 is the number of scenario
   for sc=1:9
      k1=k1+1;
      f2 = f2+(p(sc)*t(sc)*toc(i,sc)*y(k1));
   end
end
f1=0;
f1=f2; % this used in the varience of cost

%*************************************
%now calculate the varience of the cost weighted by goal programming
for sc=1:9
%*************************************
a=[8 11.7 5 4 6.0 8.7 4 5 0.14
  8 10.7 5 4 6.0 8.3 4 5 0.14
  8 10 5 4 6.0 8 4 5 0.14
  8 9.6 5 4 6.0 7.8 4 5 0.14
  8 9.3 5 4 6.0 7.5 4 5 0.14
  8 11.7 5 4 6.0 10 4 5 0.097
  8 10.7 5 4 6.3 9.7 4 5 0.097
  8 10 5 4 7.0 9.0 4 5 0.097
  8 9.6 5 4 7.4 8.6 4 5 0.097
  8 9.3 5 4 7.7 8.3 4 5 0.097
  8 11.7 5 4 6.5 10 4 5 0.1297
  8 10.7 5 4 7.3 10 4 5 0.1297
  8 10 5 4 8 10 4 5 0.1297
  8 9.6 5 4 8.4 10 4 5 0.1297
  8 9.3 5 4 8.7 10 4 5 0.1297%first
  8 12 5 4 6.0 8.7 4 5 0.1525
  8.3 11.7 5 4 6.0 8.3 4 5 0.1525
  9 11 5 4 6.0 8 4 5 0.1525
  9.4 10.6 5 4 6.0 7.8 4 5 0.1525
  9.7 10.3 5 4 6.0 7.5 4 5 0.1525
  8 12 5 4 6.0 10 4 5 0.094
  8.3 11.7 5 4 6.3 9.7 4 5 0.094
  9 11 5 4 7.0 9.0 4 5 0.094
  9.4 10.6 5 4 7.4 8.6 4 5 0.094
  9.7 10.3 5 4 7.7 8.3 4 5 0.094
  8 12 5 4 6.5 10 4 5 0.141
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  8.3 11.7 5 4 7.3 10 4 5 0.141
  9 11 5 4 8 10 4 5 0.141
  9.4 10.6 5 4 8.4 10 4 5 0.141
  9.7 10.3 5 4 8.7 10 4 5 0.141%second
  8 12 5 4 6.0 8.7 4 5 0.091
  9.3 12 5 4 6.0 8.3 4 5 0.091
  10 12 5 4 6.0 8 4 5 0.091
  10.4 12 5 4 6.0 7.8 4 5 0.091
  10.7 12 5 4 6.0 7.5 4 5 0.091
  8 12 5 4 6.0 10 4 5 0.065
  9.3 12 5 4 6.3 9.7 4 5 0.065
  10 12 5 4 7.0 9.0 4 5 0.065
  10.4 12 5 4 7.4 8.6 4 5 0.065
  10.7 12 5 4 7.7 8.3 4 5 0.065
  8 12 5 4 6.5 10 4 5 0.09
  9.3 12 5 4 7.3 10 4 5 0.09
  10 12 5 4 8 10 4 5 0.09
  10.4 12 5 4 8.4 10 4 5 0.09
  10.7 12 5 4 8.7 10 4 5 0.09%third
  ]

%solve for first scenario
alphacutsum=0;
for j=1:9%3 number of scenario
if j&&sc
   alphacutsum=p(sc)*alphacut(j)+alphacutsum;
end
end
%************************************
%now calculate the varience of the cost weighted by goal programming
   f2=f2+landa*p(sc)*(f1-alphacutsum)^2;
end
%************************************
% lack of resource
for i=1:2% 2 is the number of resources
  k1=k1+1;
   for sc=1:9
%now calculate the infeasibility penalty
   f2=f2+omega*p(sc)*(y(k1)^2);
   end
end
%******************************************
for sc=1:9
   k1=k1+1
%now calculate the infeasibility penalty
   f2=f2+omega*p(sc)*(y(k1)^2);
end

f=f2;
```