

MODEL:

!Mathematical programming model (After applying the proposed transformation approach)for the interval-stochastic multi-mode resource investment project scheduling problem (IS-MRIPSP);

SETS:

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activity/1..12/;
period1/1..59/;
period2/1..59/;
interval/1..2/;
set1(activity,interval):eft,lft;
resource/1..2/;
set2(resource,interval):K,RR,C;
nresource/1..2/;
set3(nresource,interval):NK,NK_MU,NK_STD;
set4(activity,resource,interval):E;
mode/1..3/;
derived1(activity,mode)/1 1, 2 1, 2 2, 3 1, 3 2, 3 3, 4 1, 4 2, 5 1, 6 1, 6 2, 7 1, 7 2, 7 3, 8 1, 8 2, 9 1, 10 1, 10 2,
11 1, 11 2, 11 3, 12 1/;
derived11(derived1,interval):d;
derived2(derived1,period1,period2):x;
derived3(derived1,resource,interval):kk;
derived4(derived1,nresource,interval):nkk;
precedence(activity,activity)/1 2, 1 3, 1 4, 2 5, 2 6, 2 7, 3 6, 4 7, 5 8, 5 11, 6 9, 6 11, 7 10, 7 11, 8 9, 9 12, 10
12, 11 12/;
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ENDSETS

DATA:

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d=0,0,1,3,2,4,1,3,2,5,4,6,1,2,2,4,2,3,2,3,4,6,1,2,1,2,5,7,2,4,5,8,4,6,1,3,3,6,3,5,4,6,5,8,0,0;
kk=0,0,0,0,0,2,4,8,3,6,0,2,0,1,3,5,4,8,0,1,3,5,0,1,0,2,5,8,6,8,0,1,5,8,0,2,6,10,0,1,4,8,0,2,4,6,0,1,4,6,0,0,1,3,0,1,4,8,
0,0,0,2,4,6,0,0,5,7,0,1,3,5,2,5,0,3,4,6,0,1,0,1,2,4,2,4,0,1,0,0,0,0;
nkk=0,0,0,0,2,5,0,1,0,1,4,9,0,2,6,9,5,9,0,2,4,7,0,1,6,9,0,1,3,6,0,1,0,1,2,4,4,6,0,0,0,0,5,9,5,8,0,1,0,1,4,6,0,0,1,2,0,1,
7,10,0,1,6,10,0,2,0,4,6,8,0,1,0,0,5,7,5,7,0,0,0,1,1,3,0,0,1,3,0,0,0,0;
eft=1,1,2,4,2,4,2,3,4,7,4,7,3,6,6,11,10,17,4,9,7,12,10,17;
lft=28,43,29,46,31,50,33,52,31,49,33,53,34,54,33,53,37,59,37,59,37,59,37,59;
TT=59;
NK_MU=40,43,48,52;
NK_STD=3,5,2,4;
NSAMP=10;
Prb1=0.90;
Prb2=0.90;
C=20,40,30,50;
RR=0.85,0.95,0.9,1;
E=1,1,1,1,0.9,1,0.8,0.9,0.8,0.9,0.9,0.95,0.9,0.95,0.95,1,0.85,1,0.85,1,0.8,0.9,0.8,1,0.9,1,0.9,1,0.85,0.95,
0.8,0.9,0.8,1,0.9,0.95,0.95,1,0.85,0.95,0.8,0.9,0.9,1,1,1,1,1;
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ENDDATA

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!Compromise programming with rectilinear distance metric;
Min=zx11+Zx12+Zx31+Zx32;
zx1+zx11-zx12=0;
zx3+zx31-zx32=0;
zx1=(z1-9)/(21-9);
zx3=(z3-100)/(366.6-100);

!Minimize project makespan and resource utilization costs;
z1=@sum(activity(j)|j#eq#12:@sum(mode(m)|m#eq#1:@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft)
:@sum(period2(t2)|t2#ge#@min(set1(j,i):eft)#and#
t2#le#@max(set1(j,i):lft)#and#t1#le#t2:1/2*(t1+t2)*x(j,m,t1,t2)))));
z21=@sum(resource(r):K(r,1)*C(r,1));
z22=@sum(resource(r):K(r,2)*C(r,2));
z3=((z21+z22)/2);

!Subject to;
!Constraints for mode and completion time allocation:
!(1);
@for(activity(j):@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):@sum(period
2(t2)|t2#ge#@min(set1(j,i):eft)#and#t2#le#
@max(set1(j,i):lft)#and#t1#le#t2:x(j,m,t1,t2)))=1);

!Additional constraints in the relations between completion times and activity durations:
!(2);@for(activity(j):@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):@sum(p
eriod2(t2)|t2#ge#@min(set1(j,i):eft)#and#t2#le#@max(set1(j,i):
lft)#and#t1#le#t2:d(j,m,2)*x(j,m,t1,t2)))<=(1-
teta)*@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):@sum(period2(t2)|t2#ge
#@min(set1(j,i):eft)
#and#t2#le#@max(set1(j,i):lft)#and#t1#le#t2:t1*x(j,m,t1,t2))))+teta*@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(
j,i):eft)#and#t1#le#@max(set1(j,i):lft):@sum(period2(t2)|t2#ge#@min(set1(j,i):eft)
#and#t2#le#@max(set1(j,i):lft)#and#t1#le#t2:t2*x(j,m,t1,t2)))));
!(2);@for(activity(j):@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):@sum(p
eriod2(t2)|t2#ge#@min(set1(j,i):eft)#and#t2#le#@max(set1(j,i):
lft)#and#t1#le#t2:d(j,m,1)*x(j,m,t1,t2)))<=(1-
teta)*@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):@sum(period2(t2)|t2#ge
#@min(set1(j,i):eft)
#and#t2#le#@max(set1(j,i):lft)#and#t1#le#t2:t2*x(j,m,t1,t2))))+teta*@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(
j,i):eft)#and#t1#le#@max(set1(j,i):lft):@sum(period2(t2)|t2#ge#@min(set1(j,i):eft)
#and#t2#le#@max(set1(j,i):lft)#and#t1#le#t2:t1*x(j,m,t1,t2)))));
teta=1;

!Precedence constraints;
!(3);@for(precedence(s,j):@sum(derived1(s,m):@sum(period1(t1)|t1#ge#@min(set1(s,i):eft)#and#t1#le#@max(set1(s,i):lft):@s
um(period2(t2)|t2#ge#@min(set1(s,i):eft)#and#t2#le#@max(set1(s,i):
lft)#and#t1#le#t2:t1*x(s,m,t1,t2)))<=alpha*(@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@ma
x(set1(j,i):lft):@sum(period2(t2)|t2#ge#@min(set1(j,i):eft)

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#and#t2#le#@max(set1(j,i):lft)#and#t1#le#t2:(t1-d(j,m,1))*x(j,m,t1,t2)))))+(1-
alpha)*(@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):
@sum(period2(t2)|t2#ge#@min(set1(j,i):eft)#and#t2#le#@max(set1(j,i):lft)#and#t1#le#t2:(t1-d(j,m,2))*x(j,m,t1,t2)))));
!(3);@for(precedence(s,j):@sum(derived1(s,m):@sum(period1(t1)|t1#ge#@min(set1(s,i):eft)#and#t1#le#@max(set1(s,i):lft):@s
um(period2(t2)|t2#ge#@min(set1(s,i):eft)#and#t2#le#@max(set1(s,i):
lft)#and#t1#le#t2:t2*x(s,m,t1,t2)))<=alpha*(@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@ma
x(set1(j,i):lft):@sum(period2(t2)|t2#ge#@min(set1(j,i):eft)
#and#t2#le#@max(set1(j,i):lft)#and#t1#le#t2:(t2-d(j,m,2))*x(j,m,t1,t2)))))+(1-
alpha)*(@sum(derived1(j,m):@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):
@sum(period2(t2)|t2#ge#@min(set1(j,i):eft)#and#t2#le#@max(set1(j,i):lft)#and#t1#le#t2:(t2-d(j,m,1))*x(j,m,t1,t2)))));
alpha=1;

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!Constraints for renewable resource availabilities;

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!(4);@for(resource(r):@for(period1(t1):@for(period2(t2)|t2#eq#t1:@sum(derived1(j,m):kk(j,m,r,1)/E(j,r,2)*@sum(period1(g)
|g#ge#t1#and#g#le#beta*(t1+d(j,m,1)-1)+(1-beta)*(t1+d(j,m,2)-1):
@sum(period2(f)|f#ge#g#and#f#le#TT:x(j,m,g,f))))<=((1-delta)*K(r,2)+delta*K(r,1))*RR(r,1)));
!(4);@for(resource(r):@for(period1(t1):@for(period2(t2)|t2#eq#t1:@sum(derived1(j,m):kk(j,m,r,2)/E(j,r,1)*@sum(period1(g)
|g#ge#t1#and#g#le#beta*(t1+d(j,m,1)-1)+(1-beta)*(t2+d(j,m,2)-1):
@sum(period2(f)|f#ge#g#and#f#le#TT:x(j,m,g,f))))<=((1-delta)*K(r,1)+delta*K(r,2))*RR(r,2)));
delta=1;
beta=1;

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!Chance constraints for non-renewable resource availabilities;

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!(5);@for(nresource(n):@for(interval(i)|i#eq#1:
[RESOT]@sum(derived1(j,m):nkk(j,m,n,1)*@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):@sum(per
iod2(t2)|t2#ge#@min(set1(j,i):eft)#and#t2#le#
@max(set1(j,i):lft)#and#t1#le#t2:x(j,m,t1,t2)))<=NK(n,i)););
@for(nresource(n):@for(interval(i):@SPSTGRNDV(1,NK(n,i))));
@for(nresource(n):@for(interval(i):@SPDISTNORM(NK_MU(n,i),NK_STD(n,i),NK(n,i))));
@SPCHANCE('CCP1','<=',Prb1);
@for(nresource(n):@for(interval(i)|i#eq#1:
@SPCHANCE('CCP1',RESOT)););
!(6);@for(nresource(n):@for(interval(i)|i#eq#2:
[RESOTT]
@sum(derived1(j,m):nkk(j,m,n,2)*@sum(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):@sum(period2(t2)
)|t2#ge#@min(set1(j,i):eft)#and#t2#le#
@max(set1(j,i):lft)#and#t1#le#t2:x(j,m,t1,t2)))<=NK(n,i);
)););
@SPCHANCE('CCP2','<=',Prb2);
@for(nresource(n):@for(interval(i)|i#eq#2:
@SPCHANCE('CCP2',RESOTT)););
@SPSAMPsize(1,NSAMP);
@for(resource(r):K(r,1)<=K(r,2));
@for(derived1(j,m):@for(period1(t1)|t1#ge#@min(set1(j,i):eft)#and#t1#le#@max(set1(j,i):lft):@for(period2(t2)|t2#ge#@min(
set1(j,i):eft)#and#t2#le#@max(set1(j,i):
lft)#and#t1#le#t2:@bin(x(j,m,t1,t2)))));
@for(derived1(j,m):@for(period1(t1):@for(period2(t2)|t2#lt#t1:x(j,m,t1,t2)<=0))););

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