The OperationsResearch fall-2024 problem

Summary

The goal of project is to maximize the revenue of a factory which is producing metal alloys and sends them to markets using containers. we have some limitations in different levels of problem which you can see in project doc.

Pyomo formulation

We begin by importing the Pyomo package and creating a model abstract object:

```
from pyomo.environ import *
infinity = float('inf')
model = AbstractModel(name='OR1')
```

The sets Ore, $Alloys$, $Metals$, $Factories$, $Depots$ and $Markets$ are declared abstractly using the `Set` component:

```
model.Ore = Set()
model.Alloys = Set()
model.Metals = Set()
model.Factories = Set()
model.Depots = Set()
model.Markets = Set()
```

Similarly, we add parameters, the model parameters are defined abstractly using the `Param` component:

```
M = 999999999
epsilon = 1e-9
discount_percentage = 0.05

model.min_buy_fac = Param(model.Factories,within=NonNegativeReals,
default=0.0)
model.max_buy_fac = Param(model.Factories,within=NonNegativeReals,
default=infinity)
model.discount_margin = Param(model.Factories,
within=NonNegativeReals, default=infinity)
model.contract_cost = Param(model.Factories,within= NonNegativeReals)
model.A_comb_min = Param(model.Metals, within=NonNegativeReals,
default=0.0)
model.A_comb_max = Param(model.Metals, within=NonNegativeReals,
default=infinity)
model.B_comb_min = Param(model.Metals, within=NonNegativeReals,
default=0.0)
```

```
model.B_comb_max = Param(model.Metals, within=NonNegativeReals,
default=infinity)
model.price_of_alloy_fac = Param(model.Factories, model.Alloys,
within=NonNegativeReals)
model.Max_ore = Param(model.Ore,within=NonNegativeReals)
model.Ore_cost = Param(model.Ore,within=NonNegativeReals)
model.Ore_combination = Param(model.Ore, model.Metals,
within=NonNegativeReals)
model.container_cap = Param(within= NonNegativeIntegers)
model.Container_min_to_be_sent_depot = Param(model.Factories,
model.Depots, within=NonNegativeIntegers)
model.Container_Max_to_be_sent_depot = Param(model.Factories,
model.Depots, within=NonNegativeIntegers)
model.Container_cost_to_be_sent_depot = Param(model.Factories,
model.Depots , within=NonNegativeReals)
model.depots_min_to_receive = Param(model.Depots,
within=NonNegativeIntegers)
model.depots_Max_to_receive = Param(model.Depots,
within=NonNegativeIntegers)
model.Container_min_to_be_sent_market = Param(model.Depots,
model.Markets, within= NonNegativeIntegers)
model.Container_Max_to_be_sent_market = Param(model.Depots,
model.Markets, within= NonNegativeIntegers)
model.Container_cost_to_be_sent_market =
Param(model.Depots ,model.Markets, within= NonNegativeReals)
model.Max_market_demand = Param(model.Markets,model.Alloys, within=
NonNegativeReals)
model.Market_price = Param(model.Markets , model.Alloys , within=
NonNegativeReals)
```

The `within` option here is used in these parameter declarations to define expected properties of the parameters. This information is used to perform error checks on the data that is used to initialize the parameter components.

The `Var` component is used to define the decision variables: the `binary` is `{0,1}` to be clear.

```
model.Z = Var(model.Ore,model.Alloys, within=NonNegativeReals)
model.F = Var(model.Ore,model.Alloys, within=NonNegativeReals)
model.A = Var(model.Ore,model.Alloys, within=NonNegativeReals)
model.C = Var(model.Ore,model.Alloys, within=NonNegativeReals)
model.U = Var(model.Alloys,within=NonNegativeReals)
model.t = Var(model.Alloys,model.Factories,model.Depots,
within=NonNegativeReals)
model.Extracted_ore = Var(model.Ore,within=NonNegativeReals) # defined
as S in report
model.h = Var(model.Factories,within= Binary)
model.B = Var(model.Factories, model.Depots,
within=NonNegativeIntegers)
model.g = Var(model.Alloys, model.Depots, model.Markets,
```

```
within=NonNegativeReals)
model.G = Var(model.Depots, model.Markets, within=
NonNegativeIntegers)
model.l = Var(model.Depots, model.Markets, within= Binary)
model.d = Var([1,2], within= Binary)
model.R = Var(model.Alloys,[1,2], within= NonNegativeReals,
initialize=0)
```

Rule functions are used to define constraint expressions in the `Constraint` component: here we have rule for maximum extraction of Ore:

```
def Max_extracted_ore_rule(model,i):
    return model.Extracted_ore[i] <= model.Max_ore[i]
model.Max_extracted_ore_limit =
Constraint(model.Ore,rule=Max_extracted_ore_rule)
```

Rule for Alloy weight limit(alloy weight is sum of metals weights in it):

```
def Alloy_sum_rule(model,j):
    return model.U[j] == sum(model.Z[i,j] for i in model.Ore)+\
                         sum(model.C[i,j] for i in model.Ore)+\
                         sum(model.A[i,j] for i in model.Ore)+\
                         sum(model.F[i,j] for i in model.Ore)
model.Alloy_sum_limit = Constraint(model.Alloys,rule=Alloy_sum_rule)
```

Rule for Metals in alloys(should be less than (or equal to) extracted metals from Ore):

```
def Metal_sum_rule_Z(model,i):
    return sum(model.Z[i,j] for j in model.Alloys) <=
model.Extracted_ore[i]*model.Ore_combination[i,'Zinc']
model.Metal_sum_limit_Z = Constraint(model.Ore,rule=Metal_sum_rule_Z)

def Metal_sum_rule_F(model,i):
    return sum(model.F[i,j] for j in model.Alloys) <=
model.Extracted_ore[i]*model.Ore_combination[i,'Iron']
model.Metal_sum_limit_F = Constraint(model.Ore,rule=Metal_sum_rule_F)

def Metal_sum_rule_C(model,i):
    return sum(model.C[i,j] for j in model.Alloys) <=
model.Extracted_ore[i]*model.Ore_combination[i,'Copper']
model.Metal_sum_limit_C = Constraint(model.Ore,rule=Metal_sum_rule_C)

def Metal_sum_rule_A(model,i):
    return sum(model.A[i,j] for j in model.Alloys) <=
model.Extracted_ore[i]*model.Ore_combination[i,'Aluminum']
model.Metal_sum_limit_A = Constraint(model.Ore,rule=Metal_sum_rule_A)
```

Rule for limitation of percentage of Metals in Alloys(f is bottom limit and t is top limit):

```
def Metal_in_alloy_rule_A_Z_f(model):
    value = sum(model.Z[i,'A'] for i in model.Ore)
    return model.A_comb_min['Zinc']*model.U['A']<=value
model.Metal_in_alloy_limit_A_Z_f =
Constraint(rule=Metal_in_alloy_rule_A_Z_f)
def Metal_in_alloy_rule_A_Z_t(model):
    value = sum(model.Z[i,'A'] for i in model.Ore)
    return value<=model.A_comb_max['Zinc']*model.U['A']
model.Metal_in_alloy_limit_A_Z_t =
Constraint(rule=Metal_in_alloy_rule_A_Z_t)

def Metal_in_alloy_rule_A_C_f(model):
    value = sum(model.C[i,'A'] for i in model.Ore)
    return model.A_comb_min['Copper']*model.U['A']<=value
model.Metal_in_alloy_limit_A_C_f =
Constraint(rule=Metal_in_alloy_rule_A_C_f)
def Metal_in_alloy_rule_A_C_t(model):
    value = sum(model.C[i,'A'] for i in model.Ore)
    return value<=model.A_comb_max['Copper']*model.U['A']
model.Metal_in_alloy_limit_A_C_t =
Constraint(rule=Metal_in_alloy_rule_A_C_t)

def Metal_in_alloy_rule_A_A_f(model):
    value = sum(model.A[i,'A'] for i in model.Ore)
    return model.A_comb_min['Aluminum']*model.U['A']<=value
model.Metal_in_alloy_limit_A_A_f =
Constraint(rule=Metal_in_alloy_rule_A_A_f)
def Metal_in_alloy_rule_A_A_t(model):
    value = sum(model.A[i,'A'] for i in model.Ore)
    return value<=model.A_comb_max['Aluminum']*model.U['A']
model.Metal_in_alloy_limit_A_A_t =
Constraint(rule=Metal_in_alloy_rule_A_A_t)

def Metal_in_alloy_rule_A_F_f(model):
    value = sum(model.F[i,'A'] for i in model.Ore)
    return model.A_comb_min['Iron']*model.U['A']<=value
model.Metal_in_alloy_limit_A_F_f =
Constraint(rule=Metal_in_alloy_rule_A_F_f)
def Metal_in_alloy_rule_A_F_t(model):
    value = sum(model.F[i,'A'] for i in model.Ore)
    return value<=model.A_comb_max['Iron']*model.U['A']
model.Metal_in_alloy_limit_A_F_t =
Constraint(rule=Metal_in_alloy_rule_A_F_t)

def Metal_in_alloy_rule_B_Z_f(model):
    value = sum(model.Z[i,'B'] for i in model.Ore)
    return model.B_comb_min['Zinc']*model.U['B']<=value
model.Metal_in_alloy_limit_B_Z_f =
Constraint(rule=Metal_in_alloy_rule_B_Z_f)
def Metal_in_alloy_rule_B_Z_t(model):
```

```
    value = sum(model.Z[i,'B'] for i in model.Ore)
    return value<=model.B_comb_max['Zinc']*model.U['B']
model.Metal_in_alloy_limit_B_Z_t =
Constraint(rule=Metal_in_alloy_rule_B_Z_t)

def Metal_in_alloy_rule_B_C_f(model):
    value = sum(model.C[i,'B'] for i in model.Ore)
    return model.B_comb_min['Copper']*model.U['B']<=value
model.Metal_in_alloy_limit_B_C_f =
Constraint(rule=Metal_in_alloy_rule_B_C_f)
def Metal_in_alloy_rule_B_C_t(model):
    value = sum(model.C[i,'B'] for i in model.Ore)
    return value<=model.B_comb_max['Copper']*model.U['B']
model.Metal_in_alloy_limit_B_C_t =
Constraint(rule=Metal_in_alloy_rule_B_C_t)

def Metal_in_alloy_rule_B_A_f(model):
    value = sum(model.A[i,'B'] for i in model.Ore)
    return model.B_comb_min['Aluminum']*model.U['B']<=value
model.Metal_in_alloy_limit_B_A_f =
Constraint(rule=Metal_in_alloy_rule_B_A_f)
def Metal_in_alloy_rule_B_A_t(model):
    value = sum(model.A[i,'B'] for i in model.Ore)
    return value<=model.B_comb_max['Aluminum']*model.U['B']
model.Metal_in_alloy_limit_B_A_t =
Constraint(rule=Metal_in_alloy_rule_B_A_t)

def Metal_in_alloy_rule_B_F_f(model):
    value = sum(model.F[i,'B'] for i in model.Ore)
    return model.B_comb_min['Iron']*model.U['B']<=value
model.Metal_in_alloy_limit_B_F_f =
Constraint(rule=Metal_in_alloy_rule_B_F_f)
def Metal_in_alloy_rule_B_F_t(model):
    value = sum(model.F[i,'B'] for i in model.Ore)
    return value<=model.B_comb_max['Iron']*model.U['B']
model.Metal_in_alloy_limit_B_F_t =
Constraint(rule=Metal_in_alloy_rule_B_F_t)
```

Rule for amount of exported alloy from main Factory, it should be less than(or equal to):

```
def Export_from_main_fac_rule(model,i):
    return model.U[i] >= sum(model.t[i,'Main',k] for k in
model.Depots)
model.Export_from_main_fac_limit =
Constraint(model.Alloys,rule=Export_from_main_fac_rule)
```

Rule of Limits of buying from factories:

```
def buy_from_fac_rule_f(model,i):
    value = sum(sum(model.t[j,i,k] for k in model.Depots)\
                                                    for j in model.Alloys)
    return model.min_buy_fac[i]*model.h[i]<=value
model.buy_from_fac_limit_f= Constraint([1,2],rule=buy_from_fac_rule_f)
def buy_from_fac_rule_t(model,i):
    value = sum(sum(model.t[j,i,k] for k in model.Depots)\
                                                    for j in model.Alloys)
    return value<=model.max_buy_fac[i]*model.h[i]
model.buy_from_fac_limit_t= Constraint([1,2],rule=buy_from_fac_rule_t)
```

Rule of limit for Alloys in one container from Factory to Depot:

```
def container_rule(model,i,j):
    return sum(model.t[a,i,j] for a in model.Alloys) <=
model.B[i,j]*model.container_cap
model.container_limit = Constraint(model.Factories, model.Depots,
rule=container_rule)
```

Rule of limit for transporting from fac to depots No1.:

```
def transportation_rule_t(model,i,j):
    return model.B[i,j]<=
model.Container_Max_to_be_sent_depot[i,j]*model.h[i]
model.transportation_limit_t =
Constraint(model.Factories,model.Depots, rule= transportation_rule_t)
def transportation_rule_f(model,i,j):
    return
model.Container_min_to_be_sent_depot[i,j]*model.h[i]<=model.B[i,j]
model.transportation_limit_f =
Constraint(model.Factories,model.Depots, rule= transportation_rule_f)
```

Rule of limit for transporting from fac to depots No2.:

```
def transportation_rule2(model,j):
    return inequality(model.depots_min_to_receive[j],sum(model.B[i,j]
for i in model.Factories),\
                      model.depots_Max_to_receive[j])
model.transportation_limit2 = Constraint(model.Depots,rule=
transportation_rule2)
```

Rule of limit for transporting from depots to markets:

```
def transp_from_dep_to_marker_rule(model,i,k):
    return sum(model.t[i,j,k] for j in model.Factories) >=
sum(model.g[i,k,l] for l in model.Markets)
model.transp_from_dep_to_marker_limit =
Constraint(model.Alloys,model.Depots,\
```

```
                                                        rule=
transp_from_dep_to_marker_rule)
```

Rule of limits for Alloys in containers transporting from depots to markets:

```
def container_rule2(model,i,j):
    return sum(model.g[l,i,j] for l in model.Alloys) <=
model.G[i,j]*model.container_cap
model.container_limit2 = Constraint(model.Depots, model.Markets,
rule=container_rule2)
```

Limit for containers to be sent to markets:

```
def market_sell_rule_f(model,i,j):
    return
model.Container_min_to_be_sent_market[i,j]*model.l[i,j]<=model.G[i,j]
model.market_sell_limit_f = Constraint(model.Depots,model.Markets,
rule= market_sell_rule_f)
def market_sell_rule_t(model,i,j):
    return
model.G[i,j]<=model.Container_min_to_be_sent_market[i,j]*model.l[i,j]
model.market_sell_limit_t = Constraint(model.Depots,model.Markets,
rule= market_sell_rule_t)
```

Here we have maximum market demands rule:

```
def max_market_demand_rule(model,k,i):
    return sum(model.g[i,j,k] for j in model.Depots) <=
model.Max_market_demand[k,i]
model.max_market_demand_limit = Constraint(model.Markets,
model.Alloys, rule= max_market_demand_rule)
```

The `Objective` component is used to define the revenue objective. This component uses a rule function to construct the objective expression:

$sense=maximize$ means we want to maximize the revenue.

```
def revenue_rule(model):
    return sum(sum(model.Market_price[m,j]*sum(model.g[j,k,m] for k in
model.Depots) for j in model.Alloys) for m in model.Markets)-\
           sum(model.Extracted_ore[i]*model.Ore_cost[i] for i in
model.Ore)-\
           sum(sum(model.price_of_alloy_fac[u,j]*sum(model.t[j,u,k]
for k in model.Depots) for j in model.Alloys) for u in
model.Factories)-\
           sum(model.h[u]*model.contract_cost[u] for u in
model.Factories)-\
```

```
sum(sum(model.Container_cost_to_be_sent_depot[i,j]*model.B[i,j] for j
in model.Depots) for i in model.Factories)-\

sum(sum(model.G[i,j]*model.Container_cost_to_be_sent_market[i,j] for j
in model.Markets) for i in model.Depots)

model.revenue = Objective(rule=revenue_rule, sense=maximize)
```

here is added constraints and adjusted revenue for `part B`:

```
def discount_rule_1(model,u):
    return sum(sum(model.t[j,u,k] for j in model.Alloys) for k in
model.Depots)+epsilon <= model.d[u]*model.discount_margin[u] +\

model.discount_margin[u]

def discount_rule_2(model,u):
    return sum(sum(model.t[j,u,k] for j in model.Alloys) for k in
model.Depots) >= model.discount_margin[u]*model.d[u]

def discount_rule_3(model,u,j):
    return sum(model.t[j,u,k] for k in model.Depots) >= model.R[j,u]

def discount_rule_4(model,u):
    return sum(model.R[j,u] for j in model.Alloys) <= model.d[u]*M

def revenue_rule_discount_added(model):
    return sum(sum(model.Market_price[m,j]*sum(model.g[j,k,m] for k in
model.Depots) for j in model.Alloys) for m in model.Markets)-\
           sum(model.Extracted_ore[i]*model.Ore_cost[i] for i in
model.Ore)-\
           sum(sum(model.price_of_alloy_fac[u,j]*sum(model.t[j,u,k]
for k in model.Depots) for j in model.Alloys) for u in
model.Factories)-\
           sum(model.h[u]*model.contract_cost[u] for u in
model.Factories)-\

sum(sum(model.Container_cost_to_be_sent_depot[i,j]*model.B[i,j] for j
in model.Depots) for i in model.Factories)-\

sum(sum(model.G[i,j]*model.Container_cost_to_be_sent_market[i,j] for j
in model.Markets) for i in model.Depots)+\

sum(sum(discount_percentage*model.R[j,u]*model.price_of_alloy_fac[u,j]
for u in [1,2]) for j in model.Alloys)

def apply_discount_rule():
    model.discount_limit_1 = Constraint([1,2],rule=discount_rule_1)
    model.discount_limit_2 = Constraint([1,2],rule=discount_rule_2)
    model.discount_limit_3 =
```

```
Constraint([1,2],model.Alloys,rule=discount_rule_3)
    model.discount_limit_4 = Constraint([1,2],rule=discount_rule_4)
    model.revenue = Objective(rule=revenue_rule_discount_added,
sense=maximize)
```

model data

since we have made an abstract model, we can add the data after creating model, to see the data we are feeding the model

execute command below or have a look at params.dat:

```
!cat params.dat

set Alloys:=
       A
       B;

param: Factories:          min_buy_fac  discount_margin  max_buy_fac
contract_cost:=
       1                   2000         2500             5000
120
       2                   2500         3000             6000
90
       Main                0            .                .
0   ;

param: Depots:          depots_min_to_receive  depots_Max_to_receive :=
       Tehran           20                     65
       Isfahan          30                     70   ;

param container_cap:= 100;

set Markets:=
       Mashhad
       Kerman
       Ahvaz
       Tabriz  ;

param: Metals:        A_comb_min   A_comb_max    B_comb_min
B_comb_max :=
       Iron           0            0.25          0.45         0.70
       Aluminum       0.55         1             0            0.70
       Zinc           0            0.8           0            1
       Copper         0            1             0.35         1  ;

param: Ore:                   Max_ore      Ore_cost :=
       1                      560          45
       2                      1000         65
       3                      1440          70  ;
```

```
param Ore_combination:
                        Iron    Aluminum    Zinc    Copper :=
       1                .05     .35         .25     .30
       2                .20     .30         .15     .25
       3                .05     .25         .65     .05 ;


param Container_min_to_be_sent_depot:
                      Tehran        Isfahan :=
       Main           5             5
       1              10            10
       2              5             5      ;


param Container_Max_to_be_sent_depot:
                      Tehran        Isfahan :=
       Main           20            20
       1              30            30
       2              25            15      ;

param Container_cost_to_be_sent_depot:
                      Tehran        Isfahan :=
       Main           200            230
       1              180            210
       2              240            220      ;



param Container_min_to_be_sent_market:
                      Mashhad      Kerman    Ahvaz   Tabriz :=
       Tehran         3            6         10      5
       Isfahan        4            5         5       10  ;

param Container_Max_to_be_sent_market:
                      Mashhad      Kerman    Ahvaz   Tabriz :=
       Tehran         7            12        18      15
       Isfahan        6            14        20      20  ;

param Container_cost_to_be_sent_market:
                      Mashhad      Kerman    Ahvaz   Tabriz :=
       Tehran         110          85        120     100
       Isfahan        100          100       110     90  ;



param Max_market_demand:
                      A      B :=
       Mashhad        600    400
       Kerman         800    1200
       Ahvaz          1500   1500
```

```
       Tabriz         1400   1100   ;

param Market_price:
                      A      B :=
       Mashhad        520    700
       Kerman         540    690
       Ahvaz          490    730
       Tabriz         500    710   ;


param price_of_alloy_fac:
                      A      B :=
       1              375    520
       2              390    540
       Main           0      0      ;
```

Solution

To get the result of a problem,you can execute the command below:

make sure to replace `-problem-number` with correct number, use porblem-dict.

results are also saved in `results.yaml`

```
!python model_runner.py -problem-number
```

or use code below in cases of having plots to be shown:

```
%matplotlib inline
%run model_runner.py -problem-number
```

this is problem-dictionary

```
{     '-a':'الف',     '-b':'ب',     '-c':'ج',     '-d':'د',     '-e':'ه',     '-f':'و',     '-g':'ز',     '-h':'ح',     '-i':'ط' }
```

for example you can execute the code below to see results of problem الف:

Problem A

```
!python model_runner.py -a

results for problem: -a

Problem:
- Name: unknown
  Lower bound: 1037982.72727273
  Upper bound: 1037982.72727273
  Number of objectives: 1
```

```
  Number of constraints: 97
  Number of variables: 82
  Number of nonzeros: 304
  Sense: maximize
Solver:
- Status: ok
  Termination condition: optimal
  Statistics:
    Branch and bound:
      Number of bounded subproblems: 33
      Number of created subproblems: 33
  Error rc: 0
  Time: 0.010471343994140625
Solution:
- number of solutions: 0
  number of solutions displayed: 0

Model OR1

  Variables:
    Z : Size=6, Index=Ore*Alloys
        Key      : Lower : Value             : Upper : Fixed : Stale :
Domain
        (1, 'A') :     0 :             140.0 :  None : False : False :
NonNegativeReals
        (1, 'B') :     0 :               0.0 :  None : False : False :
NonNegativeReals
        (2, 'A') :     0 :             150.0 :  None : False : False :
NonNegativeReals
        (2, 'B') :     0 :               0.0 :  None : False : False :
NonNegativeReals
        (3, 'A') :     0 :  153.69696969697 :  None : False : False :
NonNegativeReals
        (3, 'B') :     0 : 133.333333333333 :  None : False : False :
NonNegativeReals
    F : Size=6, Index=Ore*Alloys
        Key      : Lower : Value : Upper : Fixed : Stale : Domain
        (1, 'A') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (1, 'B') :     0 :  28.0 :  None : False : False :
NonNegativeReals
        (2, 'A') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (2, 'B') :     0 : 200.0 :  None : False : False :
NonNegativeReals
        (3, 'A') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (3, 'B') :     0 :  72.0 :  None : False : False :
NonNegativeReals
```

```
    A : Size=6, Index=Ore*Alloys
        Key      : Lower : Value : Upper : Fixed : Stale : Domain
        (1, 'A') :     0 : 196.0 :  None : False : False :
NonNegativeReals
        (1, 'B') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (2, 'A') :     0 : 300.0 :  None : False : False :
NonNegativeReals
        (2, 'B') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (3, 'A') :     0 : 360.0 :  None : False : False :
NonNegativeReals
        (3, 'B') :     0 :   0.0 :  None : False : False :
NonNegativeReals
    C : Size=6, Index=Ore*Alloys
        Key      : Lower : Value             : Upper : Fixed : Stale :
Domain
        (1, 'A') :     0 :               0.0 :  None : False : False :
NonNegativeReals
        (1, 'B') :     0 :             168.0 :  None : False : False :
NonNegativeReals
        (2, 'A') :     0 : 184.666666666667 :  None : False : False :
NonNegativeReals
        (2, 'B') :     0 : 65.3333333333333 :  None : False : False :
NonNegativeReals
        (3, 'A') :     0 :              72.0 :  None : False : False :
NonNegativeReals
        (3, 'B') :     0 :               0.0 :  None : False : False :
NonNegativeReals
    U : Size=2, Index=Alloys
        Key : Lower : Value             : Upper : Fixed : Stale :
Domain
          A :     0 : 1556.36363636364 :  None : False : False :
NonNegativeReals
          B :     0 : 666.666666666667 :  None : False : False :
NonNegativeReals
    t : Size=12, Index=Alloys*Factories*Depots
        Key                       : Lower : Value             : Upper :
Fixed : Stale : Domain
             ('A', 1, 'Isfahan') :     0 :               0.0 :  None :
False : False : NonNegativeReals
              ('A', 1, 'Tehran') :     0 :               0.0 :  None :
False : False : NonNegativeReals
             ('A', 2, 'Isfahan') :     0 :               0.0 :  None :
False : False : NonNegativeReals
              ('A', 2, 'Tehran') :     0 :               0.0 :  None :
False : False : NonNegativeReals
        ('A', 'Main', 'Isfahan') :     0 : 1256.36363636364 :  None :
False : False : NonNegativeReals
```

```
         ('A', 'Main', 'Tehran') :     0 :            300.0 :  None :
False : False : NonNegativeReals
             ('B', 1, 'Isfahan') :     0 : 676.969696969697 :  None :
False : False : NonNegativeReals
              ('B', 1, 'Tehran') :     0 :           1900.0 :  None :
False : False : NonNegativeReals
             ('B', 2, 'Isfahan') :     0 :              0.0 :  None :
False : False : NonNegativeReals
              ('B', 2, 'Tehran') :     0 :              0.0 :  None :
False : False : NonNegativeReals
        ('B', 'Main', 'Isfahan') :     0 : 466.666666666667 :  None :
False : False : NonNegativeReals
         ('B', 'Main', 'Tehran') :     0 :            200.0 :  None :
False : False : NonNegativeReals
    Extracted_ore : Size=3, Index=Ore
        Key : Lower : Value  : Upper : Fixed : Stale : Domain
          1 :     0 :  560.0 :  None : False : False :
NonNegativeReals
          2 :     0 : 1000.0 :  None : False : False :
NonNegativeReals
          3 :     0 : 1440.0 :  None : False : False :
NonNegativeReals
    h : Size=3, Index=Factories
        Key  : Lower : Value : Upper : Fixed : Stale : Domain
           1 :     0 :   1.0 :     1 : False : False : Binary
           2 :     0 :   0.0 :     1 : False : False : Binary
        Main :     0 :   1.0 :     1 : False : False : Binary
    B : Size=6, Index=Factories*Depots
        Key                 : Lower : Value : Upper : Fixed : Stale :
Domain
             (1, 'Isfahan') :     0 :  12.0 :  None : False : False :
NonNegativeIntegers
              (1, 'Tehran') :     0 :  19.0 :  None : False : False :
NonNegativeIntegers
             (2, 'Isfahan') :     0 :   0.0 :  None : False : False :
NonNegativeIntegers
              (2, 'Tehran') :     0 :   0.0 :  None : False : False :
NonNegativeIntegers
        ('Main', 'Isfahan') :     0 :  18.0 :  None : False : False :
NonNegativeIntegers
         ('Main', 'Tehran') :     0 :   5.0 :  None : False : False :
NonNegativeIntegers
    g : Size=16, Index=Alloys*Depots*Markets
        Key                          : Lower : Value            : Upper
: Fixed : Stale : Domain
          ('A', 'Isfahan', 'Ahvaz') :     0 :              0.0 :  None
: False : False : NonNegativeReals
         ('A', 'Isfahan', 'Kerman') :     0 :            500.0 :  None
: False : False : NonNegativeReals
```

```
        ('A', 'Isfahan', 'Mashhad') :     0 : 356.363636363636 :  None
: False : False : NonNegativeReals
         ('A', 'Isfahan', 'Tabriz') :     0 :            400.0 :  None
: False : False : NonNegativeReals
          ('A', 'Tehran', 'Ahvaz') :     0 :              0.0 :  None
: False : False : NonNegativeReals
         ('A', 'Tehran', 'Kerman') :     0 :            300.0 :  None
: False : False : NonNegativeReals
         ('A', 'Tehran', 'Mashhad') :     0 :              0.0 :  None
: False : False : NonNegativeReals
         ('A', 'Tehran', 'Tabriz') :     0 :              0.0 :  None
: False : False : NonNegativeReals
         ('B', 'Isfahan', 'Ahvaz') :     0 :            500.0 :  None
: False : False : NonNegativeReals
         ('B', 'Isfahan', 'Kerman') :     0 :              0.0 :  None
: False : False : NonNegativeReals
        ('B', 'Isfahan', 'Mashhad') :     0 : 43.6363636363637 :  None
: False : False : NonNegativeReals
         ('B', 'Isfahan', 'Tabriz') :     0 :            600.0 :  None
: False : False : NonNegativeReals
          ('B', 'Tehran', 'Ahvaz') :     0 :           1000.0 :  None
: False : False : NonNegativeReals
         ('B', 'Tehran', 'Kerman') :     0 :            300.0 :  None
: False : False : NonNegativeReals
         ('B', 'Tehran', 'Mashhad') :     0 :            300.0 :  None
: False : False : NonNegativeReals
         ('B', 'Tehran', 'Tabriz') :     0 :            500.0 :  None
: False : False : NonNegativeReals
    G : Size=8, Index=Depots*Markets
        Key                     : Lower : Value : Upper : Fixed : Stale
: Domain
         ('Isfahan', 'Ahvaz') :     0 :   5.0 :  None : False : False
: NonNegativeIntegers
         ('Isfahan', 'Kerman') :     0 :   5.0 :  None : False : False
: NonNegativeIntegers
        ('Isfahan', 'Mashhad') :     0 :   4.0 :  None : False : False
: NonNegativeIntegers
         ('Isfahan', 'Tabriz') :     0 :  10.0 :  None : False : False
: NonNegativeIntegers
          ('Tehran', 'Ahvaz') :     0 :  10.0 :  None : False : False
: NonNegativeIntegers
         ('Tehran', 'Kerman') :     0 :   6.0 :  None : False : False
: NonNegativeIntegers
         ('Tehran', 'Mashhad') :     0 :   3.0 :  None : False : False
: NonNegativeIntegers
         ('Tehran', 'Tabriz') :     0 :   5.0 :  None : False : False
: NonNegativeIntegers
    l : Size=8, Index=Depots*Markets
        Key                     : Lower : Value : Upper : Fixed : Stale
```

```
: Domain
          ('Isfahan', 'Ahvaz') :     0 :   1.0 :     1 : False : False
: Binary
         ('Isfahan', 'Kerman') :     0 :   1.0 :     1 : False : False
: Binary
        ('Isfahan', 'Mashhad') :     0 :   1.0 :     1 : False : False
: Binary
         ('Isfahan', 'Tabriz') :     0 :   1.0 :     1 : False : False
: Binary
          ('Tehran', 'Ahvaz') :     0 :   1.0 :     1 : False : False
: Binary
         ('Tehran', 'Kerman') :     0 :   1.0 :     1 : False : False
: Binary
        ('Tehran', 'Mashhad') :     0 :   1.0 :     1 : False : False
: Binary
         ('Tehran', 'Tabriz') :     0 :   1.0 :     1 : False : False
: Binary
    d : Size=2, Index={1, 2}
        Key : Lower : Value : Upper : Fixed : Stale : Domain
          1 :     0 :  None :     1 : False :  True : Binary
          2 :     0 :  None :     1 : False :  True : Binary
    R : Size=4, Index=Alloys*{1, 2}
        Key      : Lower : Value : Upper : Fixed : Stale : Domain
        ('A', 1) :     0 :     0 :  None : False :  True :
NonNegativeReals
        ('A', 2) :     0 :     0 :  None : False :  True :
NonNegativeReals
        ('B', 1) :     0 :     0 :  None : False :  True :
NonNegativeReals
        ('B', 2) :     0 :     0 :  None : False :  True :
NonNegativeReals

  Objectives:
    revenue : Size=1, Index=None, Active=True
        Key  : Active : Value
        None :   True : 1037982.7272727261

  Constraints:
    Max_extracted_ore_limit : Size=3
        Key : Lower : Body   : Upper
          1 :  None :  560.0 :   560
          2 :  None : 1000.0 :  1000
          3 :  None : 1440.0 :  1440
    Alloy_sum_limit : Size=2
        Key : Lower : Body                    : Upper
          A :  None : 2.9558577807620168e-12 :   0.0
          B :  None :  6.821210263296962e-13 :   0.0
    Metal_sum_limit_Z : Size=3
        Key : Lower : Body              : Upper
```

```
          1 :  None :                0.0 :   0.0
          2 :  None :                0.0 :   0.0
          3 :  None : -648.969696969697 :   0.0
    Metal_sum_limit_F : Size=3
        Key : Lower : Body : Upper
          1 :  None :  0.0 :   0.0
          2 :  None :  0.0 :   0.0
          3 :  None :  0.0 :   0.0
    Metal_sum_limit_C : Size=3
        Key : Lower : Body                   : Upper
          1 :  None :                  0.0 :   0.0
          2 :  None : 2.984279490192421e-13 :   0.0
          3 :  None :                  0.0 :   0.0
    Metal_sum_limit_A : Size=3
        Key : Lower : Body : Upper
          1 :  None :  0.0 :   0.0
          2 :  None :  0.0 :   0.0
          3 :  None :  0.0 :   0.0
    Metal_in_alloy_limit_A_Z_f : Size=1
        Key  : Lower : Body              : Upper
        None :  None : -443.69696969697 :   0.0
    Metal_in_alloy_limit_A_Z_t : Size=1
        Key  : Lower : Body               : Upper
        None :  None : -801.393939393942 :   0.0
    Metal_in_alloy_limit_A_C_f : Size=1
        Key  : Lower : Body                 : Upper
        None :  None : -256.66666666666697 :   0.0
    Metal_in_alloy_limit_A_C_t : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -1299.696969696973 :   0.0
    Metal_in_alloy_limit_A_A_f : Size=1
        Key  : Lower : Body                    : Upper
        None :  None : 2.0463630789890885e-12 :   0.0
    Metal_in_alloy_limit_A_A_t : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -700.3636363636399 :   0.0
    Metal_in_alloy_limit_A_F_f : Size=1
        Key  : Lower : Body : Upper
        None :  None :  0.0 :   0.0
    Metal_in_alloy_limit_A_F_t : Size=1
        Key  : Lower : Body              : Upper
        None :  None : -389.09090909091 :   0.0
    Metal_in_alloy_limit_B_Z_f : Size=1
        Key  : Lower : Body               : Upper
        None :  None : -133.333333333333 :   0.0
    Metal_in_alloy_limit_B_Z_t : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -533.3333333333339 :   0.0
    Metal_in_alloy_limit_B_C_f : Size=1
```

```
        Key  : Lower : Body                    : Upper
        None :  None : 1.1368683772161603e-13 :   0.0
    Metal_in_alloy_limit_B_C_t : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -433.33333333333366 :   0.0
    Metal_in_alloy_limit_B_A_f : Size=1
        Key  : Lower : Body : Upper
        None :  None :  0.0 :   0.0
    Metal_in_alloy_limit_B_A_t : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -466.66666666666686 :   0.0
    Metal_in_alloy_limit_B_F_f : Size=1
        Key  : Lower : Body                    : Upper
        None :  None : 1.7053025658242404e-13 :   0.0
    Metal_in_alloy_limit_B_F_t : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -166.66666666666686 :   0.0
    Export_from_main_fac_limit : Size=2
        Key : Lower : Body                  : Upper
          A :  None :                 0.0 :   0.0
          B :  None : 5.684341886080802e-14 :   0.0
    buy_from_fac_limit_f : Size=2
        Key : Lower : Body              : Upper
          1 :  None : -576.969696969697 :   0.0
          2 :  None :               0.0 :   0.0
    buy_from_fac_limit_t : Size=2
        Key : Lower : Body               : Upper
          1 :  None : -2423.030303030303 :   0.0
          2 :  None :                0.0 :   0.0
    container_limit : Size=6
        Key                  : Lower : Body               : Upper
             (1, 'Isfahan') :  None :  -523.030303030303 :   0.0
              (1, 'Tehran') :  None :                0.0 :   0.0
             (2, 'Isfahan') :  None :                0.0 :   0.0
              (2, 'Tehran') :  None :                0.0 :   0.0
        ('Main', 'Isfahan') :  None : -76.96969696969308 :   0.0
         ('Main', 'Tehran') :  None :                0.0 :   0.0
    transportation_limit_t : Size=6
        Key                  : Lower : Body  : Upper
             (1, 'Isfahan') :  None : -18.0 :   0.0
              (1, 'Tehran') :  None : -11.0 :   0.0
             (2, 'Isfahan') :  None :   0.0 :   0.0
              (2, 'Tehran') :  None :   0.0 :   0.0
        ('Main', 'Isfahan') :  None :  -2.0 :   0.0
         ('Main', 'Tehran') :  None : -15.0 :   0.0
    transportation_limit_f : Size=6
        Key                  : Lower : Body  : Upper
             (1, 'Isfahan') :  None :  -2.0 :   0.0
              (1, 'Tehran') :  None :  -9.0 :   0.0
```

```
             (2, 'Isfahan') :  None :   0.0 :   0.0
              (2, 'Tehran') :  None :   0.0 :   0.0
         ('Main', 'Isfahan') :  None : -13.0 :   0.0
          ('Main', 'Tehran') :  None :   0.0 :   0.0
    transportation_limit2 : Size=2
        Key     : Lower : Body : Upper
        Isfahan :    30 : 30.0 :  70.0
         Tehran :    20 : 24.0 :  65.0
    transp_from_dep_to_market_limit : Size=4
        Key              : Lower : Body                       : Upper
        ('A', 'Isfahan') :  None :  -3.865352482534945e-12 :   0.0
         ('A', 'Tehran') :  None :                      0.0 :   0.0
        ('B', 'Isfahan') :  None : -2.2737367544323206e-13 :   0.0
         ('B', 'Tehran') :  None :                      0.0 :   0.0
    container_limit2 : Size=8
        Key                     : Lower : Body                     :
Upper
          ('Isfahan', 'Ahvaz') :  None :                     0.0 :
0.0
         ('Isfahan', 'Kerman') :  None :                     0.0 :
0.0
        ('Isfahan', 'Mashhad') :  None : -3.268496584496461e-13 :
0.0
         ('Isfahan', 'Tabriz') :  None :                     0.0 :
0.0
           ('Tehran', 'Ahvaz') :  None :                     0.0 :
0.0
          ('Tehran', 'Kerman') :  None :                     0.0 :
0.0
         ('Tehran', 'Mashhad') :  None :                     0.0 :
0.0
          ('Tehran', 'Tabriz') :  None :                     0.0 :
0.0
    market_sell_limit_f : Size=8
        Key                     : Lower : Body : Upper
          ('Isfahan', 'Ahvaz') :  None :  0.0 :   0.0
         ('Isfahan', 'Kerman') :  None :  0.0 :   0.0
        ('Isfahan', 'Mashhad') :  None :  0.0 :   0.0
         ('Isfahan', 'Tabriz') :  None :  0.0 :   0.0
           ('Tehran', 'Ahvaz') :  None :  0.0 :   0.0
          ('Tehran', 'Kerman') :  None :  0.0 :   0.0
         ('Tehran', 'Mashhad') :  None :  0.0 :   0.0
          ('Tehran', 'Tabriz') :  None :  0.0 :   0.0
    market_sell_limit_t : Size=8
        Key                     : Lower : Body : Upper
          ('Isfahan', 'Ahvaz') :  None :  0.0 :   0.0
         ('Isfahan', 'Kerman') :  None :  0.0 :   0.0
        ('Isfahan', 'Mashhad') :  None :  0.0 :   0.0
         ('Isfahan', 'Tabriz') :  None :  0.0 :   0.0
```

```
          ('Tehran', 'Ahvaz') :  None :  0.0 :   0.0
         ('Tehran', 'Kerman') :  None :  0.0 :   0.0
        ('Tehran', 'Mashhad') :  None :  0.0 :   0.0
         ('Tehran', 'Tabriz') :  None :  0.0 :   0.0
    max_market_demand_limit : Size=8
        Key              : Lower : Body              : Upper
          ('Ahvaz', 'A') :  None :               0.0 : 1500.0
          ('Ahvaz', 'B') :  None :            1500.0 : 1500.0
         ('Kerman', 'A') :  None :             800.0 :  800.0
         ('Kerman', 'B') :  None :             300.0 : 1200.0
        ('Mashhad', 'A') :  None :  356.363636363636 :  600.0
        ('Mashhad', 'B') :  None : 343.6363636363637 :  400.0
         ('Tabriz', 'A') :  None :             400.0 : 1400.0
         ('Tabriz', 'B') :  None :            1100.0 : 1100.0
results saved in results.yaml
```

Explanation

In the report above, we have three parts, `variables`, `objective` and `constraints`, you can see value of variables in `Value` column of variables section, and as you see, value of objective(revenue) is equal to `1037982.72727273`

Problem B

```
!python model_runner.py -b

results for problem: -b
WARNING: Implicitly replacing the Component attribute revenue
(type=<class
'pyomo.core.base.objective.ScalarObjective'>) on block OR1 with a new
Component (type=<class 'pyomo.core.base.objective.ScalarObjective'>).
This is
usually indicative of a modelling error. To avoid this warning, use
block.del_component() and block.add_component().

Problem:
- Name: unknown
  Lower bound: 1107067.57575758
  Upper bound: 1107067.57575758
  Number of objectives: 1
  Number of constraints: 107
  Number of variables: 88
  Number of nonzeros: 342
  Sense: maximize
Solver:
- Status: ok
  Termination condition: optimal
  Statistics:
    Branch and bound:
      Number of bounded subproblems: 29
```

```
      Number of created subproblems: 29
  Error rc: 0
  Time: 0.010447025299072266
Solution:
- number of solutions: 0
  number of solutions displayed: 0

Model OR1

  Variables:
    Z : Size=6, Index=Ore*Alloys
        Key      : Lower : Value            : Upper : Fixed : Stale :
Domain
        (1, 'A') :     0 : 38.6666666666667 :  None : False : False :
NonNegativeReals
        (1, 'B') :     0 : 101.333333333333 :  None : False : False :
NonNegativeReals
        (2, 'A') :     0 :            150.0 :  None : False : False :
NonNegativeReals
        (2, 'B') :     0 :              0.0 :  None : False : False :
NonNegativeReals
        (3, 'A') :     0 :              0.0 :  None : False : False :
NonNegativeReals
        (3, 'B') :     0 :              0.0 :  None : False : False :
NonNegativeReals
    F : Size=6, Index=Ore*Alloys
        Key      : Lower : Value : Upper : Fixed : Stale : Domain
        (1, 'A') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (1, 'B') :     0 :  28.0 :  None : False : False :
NonNegativeReals
        (2, 'A') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (2, 'B') :     0 : 200.0 :  None : False : False :
NonNegativeReals
        (3, 'A') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (3, 'B') :     0 :   0.0 :  None : False : False :
NonNegativeReals
    A : Size=6, Index=Ore*Alloys
        Key      : Lower : Value : Upper : Fixed : Stale : Domain
        (1, 'A') :     0 : 196.0 :  None : False : False :
NonNegativeReals
        (1, 'B') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (2, 'A') :     0 : 300.0 :  None : False : False :
NonNegativeReals
        (2, 'B') :     0 :   0.0 :  None : False : False :
NonNegativeReals
```

```
        (3, 'A') :     0 :   0.0 :  None : False : False :
NonNegativeReals
        (3, 'B') :     0 :   0.0 :  None : False : False :
NonNegativeReals
    C : Size=6, Index=Ore*Alloys
        Key      : Lower : Value            : Upper : Fixed : Stale :
Domain
        (1, 'A') :     0 : 144.484848484848 :  None : False : False :
NonNegativeReals
        (1, 'B') :     0 :              0.0 :  None : False : False :
NonNegativeReals
        (2, 'A') :     0 : 72.6666666666667 :  None : False : False :
NonNegativeReals
        (2, 'B') :     0 : 177.333333333333 :  None : False : False :
NonNegativeReals
        (3, 'A') :     0 :              0.0 :  None : False : False :
NonNegativeReals
        (3, 'B') :     0 :              0.0 :  None : False : False :
NonNegativeReals
    U : Size=2, Index=Alloys
        Key : Lower : Value            : Upper : Fixed : Stale :
Domain
          A :     0 : 901.818181818182 :  None : False : False :
NonNegativeReals
          B :     0 : 506.666666666667 :  None : False : False :
NonNegativeReals
    t : Size=12, Index=Alloys*Factories*Depots
        Key                       : Lower : Value            : Upper :
Fixed : Stale : Domain
             ('A', 1, 'Isfahan') :     0 :              0.0 :  None :
False : False : NonNegativeReals
              ('A', 1, 'Tehran') :     0 :              0.0 :  None :
False : False : NonNegativeReals
             ('A', 2, 'Isfahan') :     0 :              0.0 :  None :
False : False : NonNegativeReals
              ('A', 2, 'Tehran') :     0 :              0.0 :  None :
False : False : NonNegativeReals
        ('A', 'Main', 'Isfahan') :     0 : 408.484848484848 :  None :
False : False : NonNegativeReals
         ('A', 'Main', 'Tehran') :     0 : 493.333333333333 :  None :
False : False : NonNegativeReals
             ('B', 1, 'Isfahan') :     0 : 1991.51515151515 :  None :
False : False : NonNegativeReals
              ('B', 1, 'Tehran') :     0 :           1400.0 :  None :
False : False : NonNegativeReals
             ('B', 2, 'Isfahan') :     0 :              0.0 :  None :
False : False : NonNegativeReals
              ('B', 2, 'Tehran') :     0 :              0.0 :  None :
False : False : NonNegativeReals
```

```
        ('B', 'Main', 'Isfahan') :     0 :              0.0 :  None :
False : False : NonNegativeReals
         ('B', 'Main', 'Tehran') :     0 : 506.666666666667 :  None :
False : False : NonNegativeReals
    Extracted_ore : Size=3, Index=Ore
        Key : Lower : Value  : Upper : Fixed : Stale : Domain
          1 :     0 :  560.0 :  None : False : False :
NonNegativeReals
          2 :     0 : 1000.0 :  None : False : False :
NonNegativeReals
          3 :     0 :    0.0 :  None : False : False :
NonNegativeReals
    h : Size=3, Index=Factories
        Key  : Lower : Value : Upper : Fixed : Stale : Domain
           1 :     0 :   1.0 :     1 : False : False : Binary
           2 :     0 :   0.0 :     1 : False : False : Binary
        Main :     0 :   1.0 :     1 : False : False : Binary
    B : Size=6, Index=Factories*Depots
        Key                 : Lower : Value : Upper : Fixed : Stale :
Domain
            (1, 'Isfahan') :     0 :  25.0 :  None : False : False :
NonNegativeIntegers
             (1, 'Tehran') :     0 :  14.0 :  None : False : False :
NonNegativeIntegers
            (2, 'Isfahan') :     0 :   0.0 :  None : False : False :
NonNegativeIntegers
             (2, 'Tehran') :     0 :   0.0 :  None : False : False :
NonNegativeIntegers
        ('Main', 'Isfahan') :     0 :   5.0 :  None : False : False :
NonNegativeIntegers
         ('Main', 'Tehran') :     0 :  10.0 :  None : False : False :
NonNegativeIntegers
    g : Size=16, Index=Alloys*Depots*Markets
        Key                           : Lower : Value            : Upper
: Fixed : Stale : Domain
          ('A', 'Isfahan', 'Ahvaz') :     0 :              0.0 :  None
: False : False : NonNegativeReals
         ('A', 'Isfahan', 'Kerman') :     0 :              0.0 :  None
: False : False : NonNegativeReals
        ('A', 'Isfahan', 'Mashhad') :     0 :            300.0 :  None
: False : False : NonNegativeReals
         ('A', 'Isfahan', 'Tabriz') :     0 : 108.484848484848 :  None
: False : False : NonNegativeReals
          ('A', 'Tehran', 'Ahvaz') :     0 :              0.0 :  None
: False : False : NonNegativeReals
          ('A', 'Tehran', 'Kerman') :     0 : 201.818181818182 :  None
: False : False : NonNegativeReals
         ('A', 'Tehran', 'Mashhad') :     0 :              0.0 :  None
: False : False : NonNegativeReals
```

```
          ('A', 'Tehran', 'Tabriz') :     0 : 291.515151515152 :  None
: False : False : NonNegativeReals
          ('B', 'Isfahan', 'Ahvaz') :     0 :            500.0 :  None
: False : False : NonNegativeReals
         ('B', 'Isfahan', 'Kerman') :     0 :            500.0 :  None
: False : False : NonNegativeReals
        ('B', 'Isfahan', 'Mashhad') :     0 :            100.0 :  None
: False : False : NonNegativeReals
         ('B', 'Isfahan', 'Tabriz') :     0 : 891.515151515152 :  None
: False : False : NonNegativeReals
          ('B', 'Tehran', 'Ahvaz') :     0 :           1000.0 :  None
: False : False : NonNegativeReals
          ('B', 'Tehran', 'Kerman') :     0 : 398.181818181818 :  None
: False : False : NonNegativeReals
         ('B', 'Tehran', 'Mashhad') :     0 :            300.0 :  None
: False : False : NonNegativeReals
          ('B', 'Tehran', 'Tabriz') :     0 : 208.484848484848 :  None
: False : False : NonNegativeReals
    G : Size=8, Index=Depots*Markets
        Key                     : Lower : Value : Upper : Fixed : Stale
: Domain
          ('Isfahan', 'Ahvaz') :     0 :   5.0 :  None : False : False
: NonNegativeIntegers
         ('Isfahan', 'Kerman') :     0 :   5.0 :  None : False : False
: NonNegativeIntegers
        ('Isfahan', 'Mashhad') :     0 :   4.0 :  None : False : False
: NonNegativeIntegers
         ('Isfahan', 'Tabriz') :     0 :  10.0 :  None : False : False
: NonNegativeIntegers
          ('Tehran', 'Ahvaz') :     0 :  10.0 :  None : False : False
: NonNegativeIntegers
          ('Tehran', 'Kerman') :     0 :   6.0 :  None : False : False
: NonNegativeIntegers
         ('Tehran', 'Mashhad') :     0 :   3.0 :  None : False : False
: NonNegativeIntegers
          ('Tehran', 'Tabriz') :     0 :   5.0 :  None : False : False
: NonNegativeIntegers
    l : Size=8, Index=Depots*Markets
        Key                     : Lower : Value : Upper : Fixed : Stale
: Domain
          ('Isfahan', 'Ahvaz') :     0 :   1.0 :     1 : False : False
: Binary
         ('Isfahan', 'Kerman') :     0 :   1.0 :     1 : False : False
: Binary
        ('Isfahan', 'Mashhad') :     0 :   1.0 :     1 : False : False
: Binary
         ('Isfahan', 'Tabriz') :     0 :   1.0 :     1 : False : False
: Binary
          ('Tehran', 'Ahvaz') :     0 :   1.0 :     1 : False : False
```

```
: Binary
         ('Tehran', 'Kerman') :     0 :   1.0 :     1 : False : False
: Binary
         ('Tehran', 'Mashhad') :     0 :   1.0 :     1 : False : False
: Binary
         ('Tehran', 'Tabriz') :     0 :   1.0 :     1 : False : False
: Binary
    d : Size=2, Index={1, 2}
        Key : Lower : Value : Upper : Fixed : Stale : Domain
          1 :     0 :   1.0 :     1 : False : False : Binary
          2 :     0 :   0.0 :     1 : False : False : Binary
    R : Size=4, Index=Alloys*{1, 2}
        Key      : Lower : Value            : Upper : Fixed : Stale :
Domain
        ('A', 1) :     0 :              0.0 :  None : False : False :
NonNegativeReals
        ('A', 2) :     0 :              0.0 :  None : False : False :
NonNegativeReals
        ('B', 1) :     0 : 3391.51515151515 :  None : False : False :
NonNegativeReals
        ('B', 2) :     0 :              0.0 :  None : False : False :
NonNegativeReals

  Objectives:
    revenue : Size=1, Index=None, Active=True
        Key  : Active : Value
        None :   True : 1107067.5757575764

  Constraints:
    Max_extracted_ore_limit : Size=3
        Key : Lower : Body   : Upper
          1 :  None :  560.0 :   560
          2 :  None : 1000.0 :  1000
          3 :  None :    0.0 :  1440
    Alloy_sum_limit : Size=2
        Key : Lower : Body                    : Upper
          A :  None :  5.684341886080801e-13 :   0.0
          B :  None : 1.0231815394945443e-12 :   0.0
    Metal_sum_limit_Z : Size=3
        Key : Lower : Body                    : Upper
          1 :  None : -2.984279490192421e-13 :   0.0
          2 :  None :                   0.0 :   0.0
          3 :  None :                   0.0 :   0.0
    Metal_sum_limit_F : Size=3
        Key : Lower : Body : Upper
          1 :  None :  0.0 :   0.0
          2 :  None :  0.0 :   0.0
          3 :  None :  0.0 :   0.0
    Metal_sum_limit_C : Size=3
```

```
        Key : Lower : Body                    : Upper
          1 :  None :    -23.515151515152013 :   0.0
          2 :  None : -2.984279490192421e-13 :   0.0
          3 :  None :                    0.0 :   0.0
    Metal_sum_limit_A : Size=3
        Key : Lower : Body : Upper
          1 :  None :  0.0 :   0.0
          2 :  None :  0.0 :   0.0
          3 :  None :  0.0 :   0.0
    Metal_in_alloy_limit_A_Z_f : Size=1
        Key  : Lower : Body                 : Upper
        None :  None : -188.66666666666669 :   0.0
    Metal_in_alloy_limit_A_Z_t : Size=1
        Key  : Lower : Body               : Upper
        None :  None : -532.7878787878789 :   0.0
    Metal_in_alloy_limit_A_C_f : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -217.15151515151467 :   0.0
    Metal_in_alloy_limit_A_C_t : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -684.6666666666673 :   0.0
    Metal_in_alloy_limit_A_A_f : Size=1
        Key  : Lower : Body                    : Upper
        None :  None : 1.1368683772161603e-13 :   0.0
    Metal_in_alloy_limit_A_A_t : Size=1
        Key  : Lower : Body               : Upper
        None :  None : -405.818181818182 :   0.0
    Metal_in_alloy_limit_A_F_f : Size=1
        Key  : Lower : Body : Upper
        None :  None :  0.0 :   0.0
    Metal_in_alloy_limit_A_F_t : Size=1
        Key  : Lower : Body               : Upper
        None :  None : -225.4545454545455 :   0.0
    Metal_in_alloy_limit_B_Z_f : Size=1
        Key  : Lower : Body               : Upper
        None :  None : -101.333333333333 :   0.0
    Metal_in_alloy_limit_B_Z_t : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -405.33333333333405 :   0.0
    Metal_in_alloy_limit_B_C_f : Size=1
        Key  : Lower : Body                    : Upper
        None :  None : 4.547473508864641e-13 :   0.0
    Metal_in_alloy_limit_B_C_t : Size=1
        Key  : Lower : Body                : Upper
        None :  None : -329.33333333333405 :   0.0
    Metal_in_alloy_limit_B_A_f : Size=1
        Key  : Lower : Body : Upper
        None :  None :  0.0 :   0.0
    Metal_in_alloy_limit_B_A_t : Size=1
```

```
        Key  : Lower : Body                : Upper
        None :  None : -354.6666666666669 :   0.0
    Metal_in_alloy_limit_B_F_f : Size=1
        Key  : Lower : Body                    : Upper
        None :  None : 1.7053025658242404e-13 :   0.0
    Metal_in_alloy_limit_B_F_t : Size=1
        Key  : Lower : Body                 : Upper
        None :  None : -126.66666666666691 :   0.0
    Export_from_main_fac_limit : Size=2
        Key : Lower : Body                     : Upper
          A :  None : -1.0231815394945443e-12 :   0.0
          B :  None :                     0.0 :   0.0
    buy_from_fac_limit_f : Size=2
        Key : Lower : Body                 : Upper
          1 :  None : -1391.5151515151501 :   0.0
          2 :  None :                 0.0 :   0.0
    buy_from_fac_limit_t : Size=2
        Key : Lower : Body               : Upper
          1 :  None : -1608.48484848485 :   0.0
          2 :  None :                0.0 :   0.0
    container_limit : Size=6
        Key                  : Lower : Body                 : Upper
             (1, 'Isfahan') :  None : -508.4848484848501 :   0.0
              (1, 'Tehran') :  None :                 0.0 :   0.0
             (2, 'Isfahan') :  None :                 0.0 :   0.0
              (2, 'Tehran') :  None :                 0.0 :   0.0
        ('Main', 'Isfahan') :  None : -91.51515151515201 :   0.0
         ('Main', 'Tehran') :  None :                 0.0 :   0.0
    transportation_limit_t : Size=6
        Key                  : Lower : Body  : Upper
             (1, 'Isfahan') :  None :  -5.0 :   0.0
              (1, 'Tehran') :  None : -16.0 :   0.0
             (2, 'Isfahan') :  None :   0.0 :   0.0
              (2, 'Tehran') :  None :   0.0 :   0.0
        ('Main', 'Isfahan') :  None : -15.0 :   0.0
         ('Main', 'Tehran') :  None : -10.0 :   0.0
    transportation_limit_f : Size=6
        Key                  : Lower : Body  : Upper
             (1, 'Isfahan') :  None : -15.0 :   0.0
              (1, 'Tehran') :  None :  -4.0 :   0.0
             (2, 'Isfahan') :  None :   0.0 :   0.0
              (2, 'Tehran') :  None :   0.0 :   0.0
        ('Main', 'Isfahan') :  None :   0.0 :   0.0
         ('Main', 'Tehran') :  None :  -5.0 :   0.0
    transportation_limit2 : Size=2
        Key     : Lower : Body : Upper
        Isfahan :    30 : 30.0 :  70.0
         Tehran :    20 : 24.0 :  65.0
    transp_from_dep_to_market_limit : Size=4
```

```
        Key              : Lower : Body                    : Upper
        ('A', 'Isfahan') :  None :                     0.0 :   0.0
         ('A', 'Tehran') :  None : 1.0800249583553523e-12 :   0.0
        ('B', 'Isfahan') :  None : 2.0463630789890885e-12 :   0.0
         ('B', 'Tehran') :  None : -9.094947017729282e-13 :   0.0
    container_limit2 : Size=8
        Key                     : Lower : Body                     :
Upper
          ('Isfahan', 'Ahvaz') :  None :                     0.0 :
0.0
         ('Isfahan', 'Kerman') :  None :                     0.0 :
0.0
        ('Isfahan', 'Mashhad') :  None :                     0.0 :
0.0
         ('Isfahan', 'Tabriz') :  None : -4.263256414560601e-14 :
0.0
           ('Tehran', 'Ahvaz') :  None :                     0.0 :
0.0
          ('Tehran', 'Kerman') :  None :  2.842170943040401e-14 :
0.0
         ('Tehran', 'Mashhad') :  None :                     0.0 :
0.0
          ('Tehran', 'Tabriz') :  None :                     0.0 :
0.0
    market_sell_limit_f : Size=8
        Key                     : Lower : Body : Upper
          ('Isfahan', 'Ahvaz') :  None :  0.0 :   0.0
         ('Isfahan', 'Kerman') :  None :  0.0 :   0.0
        ('Isfahan', 'Mashhad') :  None :  0.0 :   0.0
         ('Isfahan', 'Tabriz') :  None :  0.0 :   0.0
           ('Tehran', 'Ahvaz') :  None :  0.0 :   0.0
          ('Tehran', 'Kerman') :  None :  0.0 :   0.0
         ('Tehran', 'Mashhad') :  None :  0.0 :   0.0
          ('Tehran', 'Tabriz') :  None :  0.0 :   0.0
    market_sell_limit_t : Size=8
        Key                     : Lower : Body : Upper
          ('Isfahan', 'Ahvaz') :  None :  0.0 :   0.0
         ('Isfahan', 'Kerman') :  None :  0.0 :   0.0
        ('Isfahan', 'Mashhad') :  None :  0.0 :   0.0
         ('Isfahan', 'Tabriz') :  None :  0.0 :   0.0
           ('Tehran', 'Ahvaz') :  None :  0.0 :   0.0
          ('Tehran', 'Kerman') :  None :  0.0 :   0.0
         ('Tehran', 'Mashhad') :  None :  0.0 :   0.0
          ('Tehran', 'Tabriz') :  None :  0.0 :   0.0
    max_market_demand_limit : Size=8
        Key              : Lower : Body              : Upper
          ('Ahvaz', 'A') :  None :              0.0 : 1500.0
          ('Ahvaz', 'B') :  None :           1500.0 : 1500.0
         ('Kerman', 'A') :  None : 201.818181818182 :  800.0
```

```
         ('Kerman', 'B') :  None : 898.181818181818 : 1200.0
        ('Mashhad', 'A') :  None :            300.0 :  600.0
        ('Mashhad', 'B') :  None :            400.0 :  400.0
         ('Tabriz', 'A') :  None :            400.0 : 1400.0
         ('Tabriz', 'B') :  None :           1100.0 : 1100.0
    discount_limit_1 : Size=2
        Key : Lower : Body                : Upper
          1 :  None : -1608.4848484838499 :   0.0
          2 :  None :     -2999.999999999 :   0.0
    discount_limit_2 : Size=2
        Key : Lower : Body                : Upper
          1 :  None : -891.5151515151501 :   0.0
          2 :  None :                0.0 :   0.0
    discount_limit_3 : Size=4
        Key      : Lower : Body : Upper
        (1, 'A') :  None :  0.0 :   0.0
        (1, 'B') :  None :  0.0 :   0.0
        (2, 'A') :  None :  0.0 :   0.0
        (2, 'B') :  None :  0.0 :   0.0
    discount_limit_4 : Size=2
        Key : Lower : Body                : Upper
          1 :  None : -999996607.4848485 :   0.0
          2 :  None :                0.0 :   0.0
results saved in results.yaml
```

explanation

In the report above, we have three parts, `variables`, `objective` and `constraints`, you can see value of variables in `Value` column of variables section, and as you see, value of objective(revenue) is equal to `1107067.57575758`

you can see result file using code below:

```
!cat results.yaml
```

```
# ==========================================================
# = Solver Results                                         =
# ==========================================================
# ----------------------------------------------------------
#   Problem Information
# ----------------------------------------------------------
Problem:
- Name: unknown
  Lower bound: 1107067.57575758
  Upper bound: 1107067.57575758
  Number of objectives: 1
  Number of constraints: 107
  Number of variables: 88
  Number of nonzeros: 342
```

```
  Sense: maximize
# ----------------------------------------------------------
#   Solver Information
# ----------------------------------------------------------
Solver:
- Status: ok
  Termination condition: optimal
  Statistics:
    Branch and bound:
      Number of bounded subproblems: 29
      Number of created subproblems: 29
  Error rc: 0
  Time: 0.012421846389770508
# ----------------------------------------------------------
#   Solution Information
# ----------------------------------------------------------
Solution:
- number of solutions: 0
  number of solutions displayed: 0
```

Sensitivity Analysis

here we produce sensitivity analysis, be aware that, here we should eliminate binaries and integers to make sensitivity analysis, because glpk does not work with MIP(Mixed Integer Problem) problems, we will use this file later on.

```
!glpsol -m model.lp --lp --ranges sensit.sen
```

```
GLPSOL--GLPK LP/MIP Solver 5.0
Parameter(s) specified in the command line:
 -m model_test.lp --lp --ranges sensit.sen
Reading problem data from 'model_test.lp'...
115 rows, 92 columns, 366 non-zeros
862 lines were read
GLPK Simplex Optimizer 5.0
115 rows, 92 columns, 366 non-zeros
Preprocessing...
107 rows, 92 columns, 348 non-zeros
Scaling...
 A: min|aij| =  5.000e-02  max|aij| =  1.000e+09  ratio =  2.000e+10
GM: min|aij| =  1.160e-01  max|aij| =  8.621e+00  ratio =  7.433e+01
EQ: min|aij| =  1.350e-02  max|aij| =  1.000e+00  ratio =  7.408e+01
Constructing initial basis...
Size of triangular part is 107
      0: obj =  -0.000000000e+00 inf =   1.586e+03 (2)
     12: obj =  -2.613400000e+05 inf =   0.000e+00 (0)
*   114: obj =   1.107124482e+06 inf =   1.997e-10 (0)
OPTIMAL LP SOLUTION FOUND
Time used:   0.0 secs
```

```
Memory used: 0.2 Mb (203989 bytes)
Write sensitivity analysis report to 'sensit.sen'...
```

Sensit file

to see sensit.sen, we run code below:

```
!cat sensit.sen
```

```
GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page   1

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                          Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------ -------------
------------ ------------ ------------ ------------
     1 c_u_Max_extracted_ore_limit(1)_
                  NU     560.00000        .               -Inf
471.42857    -209.57253   1.64225e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                       209.57253     560.00000
628.57143          +Inf   1.67518e+06 g(B_Isfahan_Mashhad)

     2 c_u_Max_extracted_ore_limit(2)_
                  NU    1000.00000        .               -Inf
896.66667    -325.65010   1.62716e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                       325.65010    1000.00000
1077.74879         +Inf   1.68613e+06 c_u_discount_limit_4(1)_

     3 c_u_Max_extracted_ore_limit(3)_
                  NU    1440.00000        .               -Inf
1316.00000    -127.51434     1.645e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                       127.51434    1440.00000
1536.00000         +Inf   1.67305e+06 g(B_Isfahan_Mashhad)

     4 c_u_Alloy_sum_limit(A)_
                  NU        .              .               -Inf     -
576.96970        .        1.66081e+06 c_u_Metal_sum_limit_Z(3)_
                                       .              .
225.69697          +Inf   1.66081e+06 Z(3_A)

     5 c_u_Alloy_sum_limit(B)_
                  NU        .              .               -Inf     -
```

```
533.33333        .        1.66081e+06 c_u_Metal_in_alloy_limit_B_Z_t_
                                      .              .
133.33333          +Inf   1.66081e+06 c_u_Metal_in_alloy_limit_B_Z_f_

     6 c_u_Metal_sum_limit_Z(1)_
                    NU        .              .               -Inf     -
140.00000        .        1.66081e+06 Z(1_A)
                                      .              .
225.69697          +Inf   1.66081e+06 Z(3_A)

     7 c_u_Metal_sum_limit_Z(2)_
                    NU        .              .               -Inf     -
150.00000        .        1.66081e+06 Z(2_A)
                                      .              .
225.69697          +Inf   1.66081e+06 Z(3_A)

     8 c_u_Metal_sum_limit_Z(3)_
                    BS    -576.96970     576.96970          -Inf     -
648.96970        .        1.66081e+06 C(3_A)
                                      .              .              -
436.96970        .        1.66081e+06 c_u_Metal_sum_limit_Z(1)_

     9 c_u_Metal_sum_limit_F(1)_
                    NU        .              .               -Inf
-28.00000   -1097.37778   1.63009e+06 F(1_B)
                                    1097.37778        .
21.42857          +Inf   1.68433e+06 C(2_A)

    10 c_u_Metal_sum_limit_F(2)_
                    NU        .              .               -Inf     -
139.63636   -1097.37778   1.50758e+06 t(B_Main_Isfahan)
                                    1097.37778        .
21.42857          +Inf   1.68433e+06 C(2_A)

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page   2

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                        Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------- -------------
------------ ------------ ------------ ------------
    11 c_u_Metal_sum_limit_F(3)_
                    NU        .              .               -Inf
-72.00000   -1097.37778    1.5818e+06 F(3_B)
                                    1097.37778        .
```

```
21.42857          +Inf   1.68433e+06 C(2_A)

    12 c_u_Metal_sum_limit_C(1)_
                     NU        .              .                -Inf     -
168.00000        .        1.66081e+06 C(1_A)
                                              .              .
225.69697          +Inf   1.66081e+06 Z(3_A)

    13 c_u_Metal_sum_limit_C(2)_
                     NU        .              .                -Inf
-16.66667        .        1.66081e+06 C(2_A)
                                              .              .
225.69697          +Inf   1.66081e+06 Z(3_A)

    14 c_u_Metal_sum_limit_C(3)_
                     BS     -72.00000      72.00000           -Inf
-72.00000          -Inf          +Inf
                                              .              .
153.69697        .        1.66081e+06 C(3_A)

    15 c_u_Metal_sum_limit_A(1)_
                     NU        .              .                -Inf
-31.00000    -570.58182   1.64313e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                       570.58182        .
24.00000          +Inf   1.67451e+06 g(B_Isfahan_Mashhad)

    16 c_u_Metal_sum_limit_A(2)_
                     NU        .              .                -Inf
-31.00000    -570.58182   1.64313e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                       570.58182        .
24.00000          +Inf   1.67451e+06 g(B_Isfahan_Mashhad)

    17 c_u_Metal_sum_limit_A(3)_
                     NU        .              .                -Inf
-31.00000    -570.58182   1.64313e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                       570.58182        .
24.00000          +Inf   1.67451e+06 g(B_Isfahan_Mashhad)

    18 c_u_Metal_in_alloy_limit_A_Z_f_
                     BS    -515.69697     515.69697           -Inf     -
683.69697        .        1.66081e+06 c_u_Metal_sum_limit_C(1)_
                                              .              .           -
443.69697        .        1.66081e+06 C(3_A)

    19 c_u_Metal_in_alloy_limit_A_Z_t_
                     BS    -729.39394     729.39394           -Inf     -
801.39394        .        1.66081e+06 C(3_A)
```

```
                                                .              .          -
561.39394        .        1.66081e+06 c_u_Metal_sum_limit_C(1)_

    20 c_u_Metal_in_alloy_limit_A_C_f_
                     BS    -184.66667     184.66667          -Inf     -
256.66667        .        1.66081e+06 C(3_A)
                                                .              .
-16.66667        .        1.66081e+06 c_u_Metal_sum_limit_C(1)_

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page   3

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                          Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------ -------------
------------ ------------ ------------ ------------
    21 c_u_Metal_in_alloy_limit_A_C_t_
                     BS   -1371.69697    1371.69697          -Inf    -
1539.69697        .        1.66081e+06 c_u_Metal_sum_limit_C(1)_
                                                .              .          -
1299.69697        .        1.66081e+06 C(3_A)

    22 c_u_Metal_in_alloy_limit_A_A_f_
                     NU        .              .                -Inf
-31.00000    -570.58182   1.64313e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                          570.58182        .
24.00000          +Inf   1.67451e+06 g(B_Isfahan_Mashhad)

    23 c_u_Metal_in_alloy_limit_A_A_t_
                     BS    -700.36364     700.36364          -Inf     -
700.36364          -Inf          +Inf
                                                .              .          -
644.00000     313.82000   1.44103e+06 c_u_Metal_in_alloy_limit_A_A_f_

    24 c_u_Metal_in_alloy_limit_A_F_f_
                     BS        .              .                -Inf
-28.00000   -1097.37778   1.66081e+06 F(1_A)
                                                .              .
.                +Inf   1.66081e+06

    25 c_u_Metal_in_alloy_limit_A_F_t_
                     BS    -389.09091     389.09091          -Inf     -
389.09091          -Inf          +Inf
                                                .              .          -
```

```
361.09091    1097.37778   1.23383e+06 F(1_A)

    26 c_u_Metal_in_alloy_limit_B_Z_f_
                     BS    -133.33333     133.33333          -Inf     -
666.66667        .        1.66081e+06 c_u_Alloy_sum_limit(B)_
                                          .              .          -
116.66667        .        1.66081e+06 c_u_Metal_in_alloy_limit_B_C_f_

    27 c_u_Metal_in_alloy_limit_B_Z_t_
                     BS    -533.33333     533.33333          -Inf     -
550.00000        .        1.66081e+06 c_u_Metal_in_alloy_limit_B_C_f_
                                          .              .
43.63636         .       1.66081e+06 c_u_Alloy_sum_limit(B)_

    28 c_u_Metal_in_alloy_limit_B_C_f_
                     NU        .              .                -Inf
-16.66667        .        1.66081e+06 C(2_A)
                                          .              .
225.69697          +Inf   1.66081e+06 Z(3_A)

    29 c_u_Metal_in_alloy_limit_B_C_t_
                     BS    -433.33333     433.33333          -Inf     -
433.33333          -Inf          +Inf
                                          .              .          -
416.66667        .        1.66081e+06 c_u_Metal_in_alloy_limit_B_C_f_

    30 c_u_Metal_in_alloy_limit_B_A_f_
                     BS        .              .                -Inf
-31.00000    -570.58182   1.66081e+06 A(1_B)
                                          .              .
.                +Inf   1.66081e+06

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page   4

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                        Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------- ------------- ------------
    31 c_u_Metal_in_alloy_limit_B_A_t_
                     BS    -466.66667     466.66667          -Inf     -
466.66667          -Inf          +Inf
                                          .              .          -
435.66667     570.58182   1.39454e+06 A(1_B)
```

```
    32 c_u_Metal_in_alloy_limit_B_F_f_
                       NU        .             .                -Inf
-92.30769   -1097.37778   1.55952e+06 c_u_Metal_in_alloy_limit_B_Z_f_
                                          1097.37778        .
21.42857          +Inf   1.68433e+06 C(2_A)

    33 c_u_Metal_in_alloy_limit_B_F_t_
                       BS    -166.66667     166.66667          -Inf     -
166.66667          -Inf          +Inf
                                                 .              .
-23.07692     705.45714   1.54324e+06 c_u_Metal_in_alloy_limit_B_F_f_

    34 c_u_Export_from_main_fac_limit(A)_
                       NU        .             .                -Inf
-56.36364    -313.82000   1.64313e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                          313.82000        .
43.63636          +Inf   1.67451e+06 g(B_Isfahan_Mashhad)

    35 c_u_Export_from_main_fac_limit(B)_
                       NU        .             .                -Inf     -
310.30303    -493.82000   1.50758e+06 t(B_Main_Isfahan)
                                          493.82000        .
76.96345          +Inf   1.69882e+06 c_u_discount_limit_4(1)_

    36 c_u_buy_from_fac_limit_f(1)_
                       BS   -1517.97980    1517.97980          -Inf    -
1517.97980       -.42000   1.66145e+06 c_u_container_limit(2_Isfahan)_
                                                 .              .         -
1414.54545        .06000   1.66072e+06
c_u_transportation_limit_t(1_Tehran)_

    37 c_u_buy_from_fac_limit_f(2)_
                       BS        .             .                -Inf
.            -.26400   1.66081e+06 t(B_2_Tehran)
                                                 .              .
.             .03600   1.66081e+06
c_u_transportation_limit_t(2_Isfahan)_

    38 c_u_buy_from_fac_limit_t(1)_
                       BS     -70.50505      70.50505          -Inf     -
329.09091       -.02400   1.66082e+06
c_u_transportation_limit_t(1_Tehran)_
                                                 .              .
-70.50505        .16800    1.6608e+06 c_u_container_limit(2_Isfahan)_

    39 c_u_buy_from_fac_limit_t(2)_
                       BS        .             .                -Inf
.            -.01500   1.66081e+06
c_u_transportation_limit_t(2_Isfahan)_
```

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                                                    .               .
.             .11000   1.66081e+06 t(B_2_Tehran)

    40 c_u_container_limit(1_Tehran)_
                      NU        .               .               -Inf     -
310.30303      -1.82000   1.66025e+06 t(B_Main_Isfahan)
                                                 1.82000        .
84.60606          +Inf   1.66097e+06 c_u_buy_from_fac_limit_t(1)_

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page   5

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                               Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------ -------------
------------ ------------ ------------ ------------
    41 c_u_container_limit(1_Isfahan)_
                      BS    -600.00000     600.00000          -Inf    -
1223.03030      -2.12000   1.66209e+06
r_l_transportation_limit2(Isfahan)_
                                                    .               .          -
600.00000        .14000   1.66073e+06 c_u_container_limit(2_Isfahan)_

    42 c_u_container_limit(2_Tehran)_
                      NU        .               .               -Inf
.           -2.40000   1.66081e+06
c_u_transportation_limit_t(2_Tehran)_
                                                 2.40000        .
.               +Inf   1.66081e+06 B(2_Tehran)

    43 c_u_container_limit(2_Isfahan)_
                      NU        .               .               -Inf
.            -.14000   1.66081e+06 c_u_buy_from_fac_limit_f(2)_
                                                 .14000         .
.               +Inf   1.66081e+06 c_u_buy_from_fac_limit_t(2)_

    44 c_u_container_limit(Main_Tehran)_
                      NU        .               .               -Inf    -
1188.48485      -2.00000   1.65844e+06
c_u_transportation_limit_t(Main_Tehran)_
                                                 2.00000        .
311.51515          +Inf   1.66144e+06
c_u_transportation_limit_f(Main_Tehran)_

    45 c_u_container_limit(Main_Isfahan)_
```

```
                     NU        .              .                -Inf
-84.60606       -.18000    1.6608e+06 c_u_buy_from_fac_limit_t(1)_
                                              .18000         .
623.03030          +Inf   1.66093e+06
c_u_transportation_limit_f(Main_Tehran)_

    46 c_u_transportation_limit_t(1_Tehran)_
                     NU        .              .                -Inf
-3.10303      -2.00000   1.66081e+06 t(B_Main_Isfahan)
                                            2.00000         .
.84606          +Inf   1.66082e+06 c_u_buy_from_fac_limit_t(1)_

    47 c_u_transportation_limit_t(1_Isfahan)_
                     NU        .              .                -Inf
-6.23030      -2.00000    1.6608e+06
c_u_transportation_limit_f(Main_Tehran)_
                                            2.00000         .
.84606          +Inf   1.66082e+06 c_u_buy_from_fac_limit_t(1)_

    48 c_u_transportation_limit_t(2_Tehran)_
                     BS        .              .                -Inf
.           -3.60000   1.66081e+06
c_u_transportation_limit_t(2_Isfahan)_
                                              .              .
.           16.50000   1.66081e+06 t(B_2_Tehran)

    49 c_u_transportation_limit_t(2_Isfahan)_
                     NU        .              .                -Inf
.           -6.00000   1.66081e+06
c_u_transportation_limit_f(2_Isfahan)_
                                             6.00000         .
.               +Inf   1.66081e+06 c_u_buy_from_fac_limit_t(2)_

    50 c_u_transportation_limit_t(Main_Tehran)_
                     BS     -11.88485      11.88485           -Inf
-15.00000      -4.00000   1.66086e+06
c_u_transportation_limit_t(1_Isfahan)_
                                              .              .
-6.00000        .         1.66081e+06 h(Main)

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page   6

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                           Marginal   Upper bound
range         range   break point variable
```

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------ ------------ -- ------------ ------------ -------------
------------ ------------ ------------ ------------
    51 c_u_transportation_limit_t(Main_Isfahan)_
                      BS      -5.88485       5.88485          -Inf
-7.43636      -4.00000   1.66084e+06
c_u_transportation_limit_t(1_Tehran)_
                                                 .              .
6.00000        .        1.66081e+06 h(Main)

    52 c_u_transportation_limit_f(1_Tehran)_
                      BS     -10.58990      10.58990          -Inf
-12.66667      -6.00000   1.66088e+06
c_u_transportation_limit_t(1_Isfahan)_
                                                 .              .
-8.52121       3.00000   1.66078e+06
c_u_transportation_limit_t(1_Tehran)_

    53 c_u_transportation_limit_f(1_Isfahan)_
                      BS     -10.58990      10.58990          -Inf
-11.62424      -6.00000   1.66088e+06
c_u_transportation_limit_t(1_Tehran)_
                                                 .              .
-6.43636       3.00000   1.66078e+06
c_u_transportation_limit_t(1_Isfahan)_

    54 c_u_transportation_limit_f(2_Tehran)_
                      BS        .              .               -Inf
.          -33.00000   1.66081e+06 t(B_2_Tehran)
                                                 .              .
.           18.00000   1.66081e+06
c_u_transportation_limit_t(2_Isfahan)_

    55 c_u_transportation_limit_f(2_Isfahan)_
                      BS        .              .               -Inf
.          -21.00000   1.66081e+06 c_u_container_limit(2_Isfahan)_
                                                 .              .
.           18.00000   1.66081e+06
c_u_transportation_limit_t(2_Isfahan)_

    56 c_u_transportation_limit_f(Main_Tehran)_
                      BS      -3.11515       3.11515          -Inf
-4.58636        .        1.66081e+06 h(Main)
                                                 .              .
2.00000       4.00000    1.6608e+06
c_u_transportation_limit_t(1_Isfahan)_

    57 c_u_transportation_limit_f(Main_Isfahan)_
                      BS      -9.11515       9.11515          -Inf
-10.58636        .        1.66081e+06 h(Main)
                                                 .              .
```

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-7.56364       4.00000   1.66078e+06
c_u_transportation_limit_t(1_Tehran)_

    58 r_l_transportation_limit2(Tehran)_
                     BS      24.00000      -4.00000      20.00000
23.56364  -18318.00000   1.22118e+06 l(Tehran_Tabriz)
                                               .              +Inf
27.10303     182.00000   1.66518e+06 c_u_container_limit(1_Tehran)_

    59 r_u_transportation_limit2(Tehran)_
                     BS      24.00000      41.00000          -Inf
23.56364  -18318.00000   1.22118e+06 l(Tehran_Tabriz)
                                               .           65.00000
27.10303     182.00000   1.66518e+06 c_u_container_limit(1_Tehran)_

    60 r_l_transportation_limit2(Isfahan)_
                     NL      30.00000          .           30.00000
29.15394          -Inf   1.66099e+06 c_u_buy_from_fac_limit_t(1)_
                                          -212.00000          +Inf
36.23030     212.00000   1.65949e+06
c_u_transportation_limit_f(Main_Tehran)_

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page   7

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                           Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------ -------------
------------ ------------ ------------ ------------
    61 r_u_transportation_limit2(Isfahan)_
                     BS      30.00000      40.00000          -Inf
30.00000          -Inf          -Inf
                                               .           70.00000
36.23030     212.00000   1.66717e+06
r_l_transportation_limit2(Isfahan)_

    62 c_u_transp_from_dep_to_market_limit(A_Tehran)_
                     NU            .             .              -Inf
-56.36364    -315.82000   1.64301e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                          315.82000           .
43.63636          +Inf   1.67459e+06 g(B_Isfahan_Mashhad)

    63 c_u_transp_from_dep_to_market_limit(A_Isfahan)_
                     NU            .             .              -Inf
```

```
-56.36364    -314.00000   1.64312e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                        314.00000        .
43.63636          +Inf   1.67452e+06 g(B_Isfahan_Mashhad)

    64 c_u_transp_from_dep_to_market_limit(B_Tehran)_
                      NU        .             .               -Inf     -
310.30303    -495.82000   1.50696e+06 t(B_Main_Isfahan)
                                        495.82000        .
76.96345          +Inf   1.69897e+06 c_u_discount_limit_4(1)_

    65 c_u_transp_from_dep_to_market_limit(B_Isfahan)_
                      NU        .             .               -Inf
-70.50505    -494.00000   1.62598e+06 c_u_buy_from_fac_limit_t(1)_
                                        494.00000        .
76.96345          +Inf   1.69883e+06 c_u_discount_limit_4(1)_

    66 c_u_container_limit2(Tehran_Mashhad)_
                      NU        .             .               -Inf
-76.96345    -204.18000    1.6451e+06 c_u_discount_limit_4(1)_
                                        204.18000        .
56.36364          +Inf   1.67232e+06
c_u_max_market_demand_limit(Mashhad_B)_

    67 c_u_container_limit2(Tehran_Kerman)_
                      NU        .             .               -Inf
-76.96345    -194.18000   1.64587e+06 c_u_discount_limit_4(1)_
                                        194.18000        .
310.30303          +Inf   1.72107e+06 t(B_Main_Isfahan)

    68 c_u_container_limit2(Tehran_Ahvaz)_
                      NU        .             .               -Inf
-76.96345    -234.18000   1.64279e+06 c_u_discount_limit_4(1)_
                                        234.18000        .
.                +Inf   1.66081e+06
c_u_max_market_demand_limit(Ahvaz_B)_

    69 c_u_container_limit2(Tehran_Tabriz)_
                      NU        .             .               -Inf
-43.63636    -184.18000   1.65278e+06 g(B_Isfahan_Mashhad)
                                        184.18000        .
56.36364          +Inf   1.67119e+06
c_u_max_market_demand_limit(Mashhad_B)_

    70 c_u_container_limit2(Isfahan_Mashhad)_
                      NU        .             .               -Inf
-43.63636    -206.00000   1.65182e+06 g(B_Isfahan_Mashhad)
                                        206.00000        .
56.36364          +Inf   1.67242e+06
c_u_max_market_demand_limit(Mashhad_B)_
```

Problem:
Objective: revenue = 1660813.37 (MAXimum)

```
   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                                 Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------ -------------
------------ ------------ ------------ ------------
    71 c_u_container_limit2(Isfahan_Kerman)_
                     NU        .            .                -Inf
-76.96345    -196.00000   1.64573e+06 c_u_discount_limit_4(1)_
                                          196.00000        .
70.50505          +Inf   1.67463e+06 c_u_buy_from_fac_limit_t(1)_

    72 c_u_container_limit2(Isfahan_Ahvaz)_
                     NU        .            .                -Inf
-76.96345    -236.00000   1.64265e+06 c_u_discount_limit_4(1)_
                                          236.00000        .
.               +Inf   1.66081e+06
c_u_max_market_demand_limit(Ahvaz_B)_

    73 c_u_container_limit2(Isfahan_Tabriz)_
                     NU        .            .                -Inf
-43.63636    -186.00000    1.6527e+06 g(B_Isfahan_Mashhad)
                                          186.00000        .
56.36364          +Inf    1.6713e+06
c_u_max_market_demand_limit(Mashhad_B)_

    74 c_u_market_sell_limit_f(Tehran_Mashhad)_
                     BS        .            .                -Inf
.               -Inf   1.66081e+06
                                                 .             .
.76963   20308.00000   1.66081e+06
c_u_market_sell_limit_t(Tehran_Mashhad)_

    75 c_u_market_sell_limit_f(Tehran_Kerman)_
                     BS        .            .                -Inf
.               -Inf   1.66081e+06
                                                 .             .
.76963   19333.00000   1.66081e+06
c_u_market_sell_limit_t(Tehran_Kerman)_

    76 c_u_market_sell_limit_f(Tehran_Ahvaz)_
                     BS        .            .                -Inf
.               -Inf   1.66081e+06
```

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                                                    .              .
.76963   23298.00000   1.66081e+06
c_u_market_sell_limit_t(Tehran_Ahvaz)_

    77 c_u_market_sell_limit_f(Tehran_Tabriz)_
                     BS        .              .                 -Inf
.               -Inf   1.66081e+06
                                                    .              .
.43636   18318.00000   1.66081e+06
c_u_market_sell_limit_t(Tehran_Tabriz)_

    78 c_u_market_sell_limit_f(Isfahan_Mashhad)_
                     BS        .              .                 -Inf
.               -Inf   1.66081e+06
                                                    .              .
.43636   20500.00000   1.66081e+06
c_u_market_sell_limit_t(Isfahan_Mashhad)_

    79 c_u_market_sell_limit_f(Isfahan_Kerman)_
                     BS        .              .                 -Inf
.               -Inf   1.66081e+06
                                                    .              .
.76963   19500.00000   1.66081e+06
c_u_market_sell_limit_t(Isfahan_Kerman)_

    80 c_u_market_sell_limit_f(Isfahan_Ahvaz)_
                     BS        .              .                 -Inf
.               -Inf   1.66081e+06
                                                    .              .
.76963   23490.00000   1.66081e+06
c_u_market_sell_limit_t(Isfahan_Ahvaz)_

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page   9

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                          Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------- ------------- ------------
    81 c_u_market_sell_limit_f(Isfahan_Tabriz)_
                     BS        .              .                 -Inf
.               -Inf   1.66081e+06
                                                    .              .
.43636   18510.00000   1.66081e+06
c_u_market_sell_limit_t(Isfahan_Tabriz)_
```

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    82 c_u_market_sell_limit_t(Tehran_Mashhad)_
                       NU        .             .                -Inf
.       -20308.00000   1.66081e+06
c_u_market_sell_limit_f(Tehran_Mashhad)_
                                             20308.00000         .
.56364          +Inf   1.67226e+06
c_u_max_market_demand_limit(Mashhad_B)_

    83 c_u_market_sell_limit_t(Tehran_Kerman)_
                       NU        .             .                -Inf
.       -19333.00000   1.66081e+06
c_u_market_sell_limit_f(Tehran_Kerman)_
                                             19333.00000         .
3.10303          +Inf    1.7208e+06 t(B_Main_Isfahan)

    84 c_u_market_sell_limit_t(Tehran_Ahvaz)_
                       NU        .             .                -Inf
.       -23298.00000   1.66081e+06
c_u_market_sell_limit_f(Tehran_Ahvaz)_
                                             23298.00000         .
.               +Inf   1.66081e+06
c_u_max_market_demand_limit(Ahvaz_B)_

    85 c_u_market_sell_limit_t(Tehran_Tabriz)_
                       NU        .             .                -Inf
.       -18318.00000   1.66081e+06
c_u_market_sell_limit_f(Tehran_Tabriz)_
                                             18318.00000         .
.56364          +Inf   1.67114e+06
c_u_max_market_demand_limit(Mashhad_B)_

    86 c_u_market_sell_limit_t(Isfahan_Mashhad)_
                       NU        .             .                -Inf
.       -20500.00000   1.66081e+06
c_u_market_sell_limit_f(Isfahan_Mashhad)_
                                             20500.00000         .
.56364          +Inf   1.67237e+06
c_u_max_market_demand_limit(Mashhad_B)_

    87 c_u_market_sell_limit_t(Isfahan_Kerman)_
                       NU        .             .                -Inf
.       -19500.00000   1.66081e+06
c_u_market_sell_limit_f(Isfahan_Kerman)_
                                             19500.00000         .
.70505          +Inf   1.67456e+06 c_u_buy_from_fac_limit_t(1)_

    88 c_u_market_sell_limit_t(Isfahan_Ahvaz)_
                       NU        .             .                -Inf
.       -23490.00000   1.66081e+06
```

```
c_u_market_sell_limit_f(Isfahan_Ahvaz)_
                                        23490.00000         .
.               +Inf   1.66081e+06
c_u_max_market_demand_limit(Ahvaz_B)_

    89 c_u_market_sell_limit_t(Isfahan_Tabriz)_
                     NU         .              .                -Inf
.       -18510.00000   1.66081e+06
c_u_market_sell_limit_f(Isfahan_Tabriz)_
                                        18510.00000         .
.56364          +Inf   1.67125e+06
c_u_max_market_demand_limit(Mashhad_B)_

    90 c_u_max_market_demand_limit(Mashhad_A)_
                       BS     356.36364     243.63636           -Inf
300.00000     -30.00000   1.65012e+06
c_u_max_market_demand_limit(Tabriz_B)_
                                                 .           600.00000
400.00000      30.00000    1.6715e+06
c_u_max_market_demand_limit(Kerman_A)_

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page  10

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                              Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------ -------------
------------ ------------ ------------ ------------
    91 c_u_max_market_demand_limit(Mashhad_B)_
                       BS     343.63636      56.36364           -Inf
300.00000     -30.00000    1.6505e+06
c_u_max_market_demand_limit(Kerman_A)_
                                                 .           400.00000
700.00000      30.00000   1.67112e+06
c_u_max_market_demand_limit(Tabriz_B)_

    92 c_u_max_market_demand_limit(Kerman_A)_
                       NU     800.00000         .                -Inf
756.36364     -30.00000    1.6595e+06 g(B_Isfahan_Mashhad)
                                              30.00000     800.00000
856.36364          +Inf    1.6625e+06
c_u_max_market_demand_limit(Mashhad_B)_

    93 c_u_max_market_demand_limit(Kerman_B)_
                       BS     300.00000     900.00000           -Inf
```

```
223.03655    -193.33000   1.60281e+06 l(Tehran_Kerman)
                                      .         1200.00000
343.63636      30.00000   1.66981e+06
c_u_max_market_demand_limit(Kerman_A)_

    94 c_u_max_market_demand_limit(Ahvaz_A)_
                     BS        .         1500.00000          -Inf
.               -Inf   1.66081e+06
                                      .         1500.00000
56.36364      60.00000   1.66081e+06 g(A_Isfahan_Ahvaz)

    95 c_u_max_market_demand_limit(Ahvaz_B)_
                     BS    1500.00000        .               -Inf
1443.63636     -60.00000   1.57081e+06 g(A_Isfahan_Ahvaz)
                                      .         1500.00000
1500.00000          +Inf          +Inf

    96 c_u_max_market_demand_limit(Tabriz_A)_
                     BS     400.00000    1000.00000          -Inf
356.36364    -183.18000   1.58754e+06 l(Tehran_Tabriz)
                                      .         1400.00000
456.36364      30.00000   1.67281e+06
c_u_max_market_demand_limit(Tabriz_B)_

    97 c_u_max_market_demand_limit(Tabriz_B)_
                     NU    1100.00000        .               -Inf
1043.63636     -30.00000   1.65912e+06
c_u_max_market_demand_limit(Mashhad_B)_
                                        30.00000    1100.00000
1143.63636          +Inf   1.66212e+06 g(B_Isfahan_Mashhad)

    98 c_u_discount_limit_1(1)_
                     NU    2500.00000        .               -Inf
76.96970        .        1.66081e+06 d(1)
                                      .         2500.00000
2576.96325          +Inf   1.66081e+06 c_u_discount_limit_4(1)_

    99 c_u_discount_limit_1(2)_
                     BS        .         3000.00000          -Inf
.               -Inf   1.66081e+06
                                      .         3000.00000
.           19.14006   1.66081e+06 c_u_discount_limit_2(2)_

   100 c_u_discount_limit_2(1)_
                     BS   -2500.00000    2500.00000          -Inf    -
2500.00000          -Inf          +Inf
                                      .              .
-76.96970        .        1.66081e+06 c_u_discount_limit_1(1)_

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
```

Problem:
Objective: revenue = 1660813.37 (MAXimum)

```
   No. Row name     St      Activity         Slack   Lower bound
Activity      Obj coef  Obj value at Limiting
                                                    Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------ -------------
------------ ------------ ------------ ------------
   101 c_u_discount_limit_2(2)_
                     NU        .              .               -Inf
.          -19.14006   1.66081e+06 c_u_buy_from_fac_limit_f(2)_
                                                    19.14006        .
.              +Inf   1.66081e+06 c_u_buy_from_fac_limit_t(2)_

   102 c_u_discount_limit_3(1_A)_
                     NU        .              .               -Inf
.          -18.75000   1.66081e+06 R(A_1)
                                                    18.75000        .
3.07853e+07          +Inf   5.78885e+08 c_u_discount_limit_4(1)_

   103 c_u_discount_limit_3(1_B)_
                     NU        .              .               -Inf    -
2576.96970     -26.00000   1.59381e+06 R(B_1)
                                                    26.00000        .
3.07853e+07          +Inf   8.02079e+08 c_u_discount_limit_4(1)_

   104 c_u_discount_limit_3(2_A)_
                     NU        .              .               -Inf
.          -19.49994   1.66081e+06 R(A_2)
                                                    19.49994        .
.              +Inf   1.66081e+06 c_u_buy_from_fac_limit_f(2)_

   105 c_u_discount_limit_3(2_B)_
                     NU        .              .               -Inf
.          -26.99994   1.66081e+06 R(B_2)
                                                    26.99994        .
.              +Inf   1.66081e+06 c_u_buy_from_fac_limit_f(2)_

   106 c_u_discount_limit_4(1)_
                     BS  -3.07853e+07   3.07853e+07          -Inf    -
9.99997e+08        .        1.66081e+06 c_u_discount_limit_1(1)_
                                                       .            .        -
3.07853e+07        .00005   1.65934e+06 c_u_discount_limit_4(2)_

   107 c_u_discount_limit_4(2)_
                     NU        .              .               -Inf
.            -.00006   1.66081e+06 c_u_buy_from_fac_limit_f(2)_
```

```
                                                  .00006        .
.               +Inf   1.66081e+06 c_u_buy_from_fac_limit_t(2)_

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page  12

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                          Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------- ------------- ------------
     1 g(A_Tehran_Mashhad)
                   NL        .          520.00000        .
-43.63636          -Inf   1.66081e+06 g(B_Isfahan_Mashhad)
                                             .                +Inf
300.00000     520.00000   1.66081e+06 g(B_Tehran_Mashhad)

     2 g(A_Tehran_Kerman)
                   BS     300.00000     540.00000        .
256.36364     510.00000   1.65181e+06
c_u_max_market_demand_limit(Kerman_A)_
                                             .                +Inf
600.00000     540.00000   1.66081e+06 g(B_Isfahan_Kerman)

     3 g(A_Tehran_Ahvaz)
                   NL        .          490.00000        .
.               -Inf   1.66081e+06
c_u_max_market_demand_limit(Ahvaz_B)_
                                          -60.00000           +Inf
56.36364     550.00000   1.65743e+06
c_u_max_market_demand_limit(Mashhad_B)_

     4 g(A_Tehran_Tabriz)
                   NL        .          500.00000        .          -
155.15152          -Inf   1.66081e+06 t(B_Main_Isfahan)
                                             .                +Inf
400.00000     500.00000   1.66081e+06 g(A_Isfahan_Tabriz)

     5 g(A_Isfahan_Mashhad)
                   BS     356.36364     520.00000        .
56.36364     520.00000   1.66081e+06 g(A_Tehran_Mashhad)
                                             .                +Inf
400.00000     550.00000    1.6715e+06
c_u_max_market_demand_limit(Kerman_A)_

     6 g(A_Isfahan_Kerman)
```

```
                     BS     500.00000     540.00000         .
200.00000     540.00000   1.66081e+06 g(B_Isfahan_Kerman)
                                             .               +Inf
500.00000          +Inf          +Inf

     7 g(A_Isfahan_Ahvaz)
                     NL         .          490.00000         .
.               -Inf   1.66081e+06
c_u_max_market_demand_limit(Ahvaz_B)_
                                          -60.00000          +Inf
56.36364     550.00000   1.65743e+06
c_u_max_market_demand_limit(Mashhad_B)_

     8 g(A_Isfahan_Tabriz)
                     BS     400.00000     500.00000         .           -
100.00000     500.00000   1.66081e+06 g(A_Tehran_Tabriz)
                                             .               +Inf
456.36364     530.00000   1.67281e+06
c_u_max_market_demand_limit(Tabriz_B)_

     9 g(B_Tehran_Mashhad)
                     BS     300.00000     700.00000         .
-56.36364     700.00000   1.66081e+06 g(A_Tehran_Mashhad)
                                             .               +Inf
300.00000          +Inf          +Inf

    10 g(B_Tehran_Kerman)
                     BS     300.00000     690.00000         .           -
200.00000     690.00000   1.66081e+06 g(B_Isfahan_Kerman)
                                             .               +Inf
343.63636     720.00000   1.66981e+06
c_u_max_market_demand_limit(Kerman_A)_

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page  13

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                          Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------- ------------- ------------
    11 g(B_Tehran_Ahvaz)
                     BS    1000.00000     730.00000         .
943.63636     670.00000   1.60081e+06 g(A_Tehran_Ahvaz)
                                             .               +Inf
1000.00000          +Inf          +Inf
```

```
    12 g(B_Tehran_Tabriz)
                      BS     500.00000     710.00000         .
100.00000     710.00000   1.66081e+06 g(A_Tehran_Tabriz)
                                                 .               +Inf
500.00000          +Inf          +Inf

    13 g(B_Isfahan_Mashhad)
                      BS      43.63636     700.00000         .           -
111.51515     670.00000    1.6595e+06
c_u_max_market_demand_limit(Kerman_A)_
                                                 .               +Inf
343.63636     700.00000   1.66081e+06 g(A_Tehran_Mashhad)

    14 g(B_Isfahan_Kerman)
                      NL         .          690.00000         .           -
155.15152          -Inf   1.66081e+06 t(B_Main_Isfahan)
                                                 .               +Inf
300.00000     690.00000   1.66081e+06 g(B_Tehran_Kerman)

    15 g(B_Isfahan_Ahvaz)
                      BS     500.00000     730.00000         .
443.63636     670.00000   1.63081e+06 g(A_Isfahan_Ahvaz)
                                                 .               +Inf
500.00000          +Inf          +Inf

    16 g(B_Isfahan_Tabriz)
                      BS     600.00000     710.00000         .
543.63636     680.00000   1.64281e+06
c_u_max_market_demand_limit(Tabriz_B)_
                                                 .               +Inf
1000.00000     710.00000   1.66081e+06 g(A_Tehran_Tabriz)

    17 Extracted_ore(1)
                      BS     560.00000     -45.00000         .
471.42857    -254.57253   1.54345e+06 c_u_Max_extracted_ore_limit(1)_
                                                 .               +Inf
560.00000          +Inf          +Inf

    18 Extracted_ore(2)
                      BS    1000.00000     -65.00000         .
896.66667    -390.65010   1.33516e+06 c_u_Max_extracted_ore_limit(2)_
                                                 .               +Inf
1000.00000          +Inf          +Inf

    19 Extracted_ore(3)
                      BS    1440.00000     -70.00000         .
1316.00000    -197.51434   1.47719e+06 c_u_Max_extracted_ore_limit(3)_
                                                 .               +Inf
1440.00000          +Inf          +Inf
```

```
    20 t(A_1_Tehran)
                      NL        .          -375.00000         .
.               -Inf   1.66081e+06 R(A_1)
                                             -42.25000          +Inf
43.63636    -332.75000   1.65897e+06 g(B_Isfahan_Mashhad)

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page  14

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                             Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------- ------------- ------------
    21 t(A_1_Isfahan)
                      NL        .          -375.00000         .
.               -Inf   1.66081e+06 R(A_1)
                                             -42.25000          +Inf
43.63636    -332.75000   1.65897e+06 g(B_Isfahan_Mashhad)

    22 t(A_2_Tehran)
                      NL        .          -390.00000         .
.               -Inf   1.66081e+06 R(A_2)
                                             -37.94000          +Inf
.         -352.06000   1.66081e+06 c_u_buy_from_fac_limit_t(2)_

    23 t(A_2_Isfahan)
                      NL        .          -390.00000         .
.               -Inf   1.66081e+06 R(A_2)
                                             -37.50000          +Inf
.         -352.50000   1.66081e+06 t(B_2_Isfahan)

    24 t(B_1_Tehran)
                      BS    1588.48485    -520.00000         .
1433.33333    -520.04000   1.66075e+06
c_u_transportation_limit_t(1_Tehran)_
                                                 .               +Inf
1900.00000    -519.96000   1.66088e+06
c_u_transportation_limit_t(1_Isfahan)_

    25 t(B_1_Isfahan)
                      BS     988.48485    -520.00000         .
676.96970    -520.04000   1.66077e+06
c_u_transportation_limit_t(1_Isfahan)_
                                                 .               +Inf
```

```
1143.63636    -519.96000   1.66085e+06
c_u_transportation_limit_t(1_Tehran)_

    26 t(B_2_Tehran)
                      NL        .          -540.00000        .
.               -Inf   1.66081e+06 B(2_Tehran)
                                            -.44000          +Inf
.         -539.56000   1.66081e+06 c_u_buy_from_fac_limit_t(2)_

    27 t(B_2_Isfahan)
                      BS        .          -540.00000        .
.         -540.44000   1.66081e+06 t(B_2_Tehran)
                                               .               +Inf
.         -520.86000   1.66081e+06 c_u_discount_limit_4(2)_

    28 h(1)           BS        .52949    -120.00000        .
.52949    -960.00000   1.66037e+06 c_u_container_limit(2_Isfahan)_
                                               .            1.00000
.58121        .        1.66088e+06
c_u_transportation_limit_t(1_Tehran)_

    29 h(2)           BS        .           -90.00000        .
.         -750.00000   1.66081e+06 t(B_2_Tehran)
                                               .            1.00000
.             .        1.66081e+06
c_u_transportation_limit_t(2_Isfahan)_

    30 B(1_Tehran)  BS      15.88485    -180.00000        .
14.33333    -184.00000   1.66075e+06
c_u_transportation_limit_t(1_Tehran)_
                                               .               +Inf
19.00000    -176.00000   1.66088e+06
c_u_transportation_limit_t(1_Isfahan)_

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page  15

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                            Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------- ------------- ------------
    31 B(1_Isfahan) BS      15.88485    -210.00000        .
12.76970    -214.00000   1.66075e+06
c_u_transportation_limit_t(1_Isfahan)_
                                               .               +Inf
```

```
17.43636    -206.00000   1.66088e+06
c_u_transportation_limit_t(1_Tehran)_

    32 B(2_Tehran)  BS        .          -240.00000        .
.               -Inf   1.66081e+06
                                                .                +Inf
.         -196.00000   1.66081e+06 t(B_2_Tehran)

    33 B(2_Isfahan) BS        .          -220.00000        .
.         -264.00000   1.66081e+06 t(B_2_Tehran)
                                                .                +Inf
.         -206.00000   1.66081e+06 c_u_container_limit(2_Isfahan)_

    34 B(Main_Tehran)
                     BS       8.11515    -200.00000        .
5.00000    -204.00000   1.66078e+06
c_u_transportation_limit_t(1_Isfahan)_
                                                .                +Inf
9.66667    -196.00000   1.66085e+06
c_u_transportation_limit_t(1_Tehran)_

    35 B(Main_Isfahan)
                     BS      14.11515    -230.00000        .
12.56364    -234.00000   1.66076e+06
c_u_transportation_limit_t(1_Tehran)_
                                                .                +Inf
17.23030    -226.00000   1.66087e+06
c_u_transportation_limit_t(1_Isfahan)_

    36 G(Tehran_Mashhad)
                     BS       3.00000    -110.00000        .
2.23037  -20418.00000   1.59989e+06 l(Tehran_Mashhad)
                                                .                +Inf
3.00000          +Inf          +Inf

    37 G(Tehran_Kerman)
                     BS       6.00000     -85.00000        .
5.23037  -19418.00000   1.54482e+06 l(Tehran_Kerman)
                                                .                +Inf
6.00000          +Inf          +Inf

    38 G(Tehran_Ahvaz)
                     BS      10.00000    -120.00000        .
9.23037  -23418.00000   1.42783e+06 l(Tehran_Ahvaz)
                                                .                +Inf
10.00000          +Inf          +Inf

    39 G(Tehran_Tabriz)
                     BS       5.00000    -100.00000        .
4.56364  -18418.00000   1.56922e+06 l(Tehran_Tabriz)
```

```
                                                    .                +Inf
5.00000          +Inf          +Inf

    40 G(Isfahan_Mashhad)
                       BS       4.00000    -100.00000         .
3.56364  -20600.00000   1.57881e+06 l(Isfahan_Mashhad)
                                                    .                +Inf
4.00000          +Inf          +Inf

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page  16

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                                    Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------ -------------
------------ ------------ ------------ ------------
    41 G(Isfahan_Kerman)
                       BS       5.00000    -100.00000         .
4.23037  -19600.00000   1.56331e+06 l(Isfahan_Kerman)
                                                    .                +Inf
5.00000          +Inf          +Inf

    42 G(Isfahan_Ahvaz)
                       BS       5.00000    -110.00000         .
4.23037  -23600.00000   1.54336e+06 l(Isfahan_Ahvaz)
                                                    .                +Inf
5.00000          +Inf          +Inf

    43 G(Isfahan_Tabriz)
                       BS      10.00000     -90.00000         .
9.56364  -18600.00000   1.47571e+06 l(Isfahan_Tabriz)
                                                    .                +Inf
10.00000          +Inf          +Inf

    44 R(A_1)          BS              .            18.75000         .
-Inf          .         1.66081e+06 c_u_discount_limit_3(1_A)_
                                                    .                +Inf
43.63636      61.00000   1.66081e+06 t(A_1_Tehran)

    45 R(A_2)          BS              .            19.50000         .
.             .00006   1.66081e+06 c_u_discount_limit_3(2_A)_
                                                    .                +Inf
.           57.00000   1.66081e+06 t(A_2_Isfahan)

    46 R(B_1)          BS    2576.96970      26.00000         .
```

```
2576.96970       6.86000   1.61149e+06 c_u_discount_limit_4(2)_
                                       .               +Inf
2647.11111     251.42714   2.24173e+06 c_u_Max_extracted_ore_limit(3)_

    47 R(B_2)       BS         .           27.00000        .
.             .00014   1.66081e+06 c_u_discount_limit_3(2_B)_
                                       .               +Inf
.           46.14000   1.66081e+06 c_u_discount_limit_4(2)_

    48 U(A)         BS    1556.36364        .             .
1500.00000    -280.53156    1.2242e+06 c_u_Max_extracted_ore_limit(3)_
                                       .               +Inf
1556.36364          +Inf          +Inf

    49 Z(1_A)       BS     140.00000        .             .          -
436.96970        .        1.66081e+06 c_u_Metal_sum_limit_Z(1)_
                                       .               +Inf
140.00000          +Inf          +Inf

    50 Z(2_A)       BS     150.00000        .             .
16.66667         .        1.66081e+06 Z(2_B)
                                       .               +Inf
150.00000          +Inf          +Inf

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page  17

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                       Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------- ------------- ------------
    51 Z(3_A)       BS     225.69697        .             .
153.69697        .        1.66081e+06 C(3_A)
                                       .               +Inf
365.69697        .        1.66081e+06 c_u_Metal_sum_limit_Z(1)_

    52 C(1_A)       BS     168.00000        .             .
-65.33333        .        1.66081e+06 C(1_B)
                                       .               +Inf
168.00000          +Inf          +Inf

    53 C(2_A)       BS      16.66667        .             .          -
168.00000        .        1.66081e+06 c_u_Metal_sum_limit_C(2)_
                                       .               +Inf
184.66667        .        1.66081e+06 C(1_B)
```

```
    54 C(3_A)       NL        .              .              .          -
184.66667          -Inf   1.66081e+06 c_u_Metal_in_alloy_limit_A_C_f_
                                         .                 +Inf
72.00000        .        1.66081e+06 c_u_Metal_sum_limit_C(3)_

    55 A(1_A)       BS     196.00000        .              .
165.00000    -570.58182   1.54898e+06 A(1_B)
                                         .                 +Inf
196.00000          +Inf          +Inf

    56 A(2_A)       BS     300.00000        .              .
269.00000    -570.58182   1.48964e+06 A(2_B)
                                         .                 +Inf
300.00000          +Inf          +Inf

    57 A(3_A)       BS     360.00000        .              .
329.00000    -510.05737   1.47719e+06 c_u_Max_extracted_ore_limit(3)_
                                         .                 +Inf
360.00000          +Inf          +Inf

    58 F(1_A)       NL        .              .              .
.               -Inf   1.66081e+06 c_u_Metal_in_alloy_limit_A_F_f_
                                      -1097.37778          +Inf
28.00000    1097.37778   1.63009e+06 F(1_B)

    59 F(2_A)       NL        .              .              .
.               -Inf   1.66081e+06 c_u_Metal_in_alloy_limit_A_F_f_
                                      -1097.37778          +Inf
126.95455    1097.37778    1.5215e+06 Z(3_A)

    60 F(3_A)       NL        .              .              .
.               -Inf   1.66081e+06 c_u_Metal_in_alloy_limit_A_F_f_
                                      -1097.37778          +Inf
72.00000    1097.37778    1.5818e+06 F(3_B)

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page  18

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                         Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------- ------------- ------------
    61 U(B)         BS     666.66667        .              .
604.44444    -493.82000    1.3316e+06 F(1_A)
```

```
                                                .                +Inf
666.66667          +Inf          +Inf

    62 Z(1_B)       NL        .               .               .           -
225.69697          -Inf   1.66081e+06 Z(3_A)
                                                .                +Inf
133.33333        .        1.66081e+06 Z(3_B)

    63 Z(2_B)       NL        .               .               .           -
225.69697          -Inf   1.66081e+06 Z(3_A)
                                                .                +Inf
133.33333        .        1.66081e+06 Z(3_B)

    64 Z(3_B)       BS     133.33333        .               .
-6.66667         .        1.66081e+06 Z(1_B)
                                                .                +Inf
666.66667         .        1.66081e+06 c_u_Alloy_sum_limit(B)_

    65 C(1_B)       NL        .               .               .
-16.66667          -Inf   1.66081e+06 C(2_A)
                                                .                +Inf
168.00000         .        1.66081e+06 C(1_A)

    66 C(2_B)       BS     233.33333        .               .
65.33333         .        1.66081e+06 C(1_B)
                                                .                +Inf
250.00000         .        1.66081e+06 c_u_Metal_in_alloy_limit_B_C_f_

    67 C(3_B)       NL        .               .               .
-16.66667          -Inf   1.66081e+06 C(2_A)
                                                .                +Inf
72.00000         .        1.66081e+06 c_u_Metal_sum_limit_C(3)_

    68 A(1_B)       NL        .               .               .
.                -Inf   1.66081e+06 c_u_Metal_in_alloy_limit_B_A_f_
                                          -570.58182          +Inf
31.00000     570.58182   1.64313e+06
c_u_max_market_demand_limit(Mashhad_B)_

    69 A(2_B)       NL        .               .               .
.                -Inf   1.66081e+06 c_u_Metal_in_alloy_limit_B_A_f_
                                          -570.58182          +Inf
31.00000     570.58182   1.64313e+06
c_u_max_market_demand_limit(Mashhad_B)_

    70 A(3_B)       NL        .               .               .
.                -Inf   1.66081e+06 c_u_Metal_in_alloy_limit_B_A_f_
                                          -570.58182          +Inf
31.00000     570.58182   1.64313e+06
c_u_max_market_demand_limit(Mashhad_B)_
```

Problem:
Objective: revenue = 1660813.37 (MAXimum)

```
   No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                                    Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------ ------------ -------------
------------- ------------ ------------ ------------
    71 F(1_B)       BS      28.00000        .               .
-98.95455   -1097.37778   1.63009e+06 F(1_A)
                                                    .               +Inf
28.00000          +Inf          +Inf

    72 F(2_B)       BS     200.00000        .               .
73.04545   -1097.37778   1.44134e+06 F(2_A)
                                                    .               +Inf
200.00000          +Inf          +Inf

    73 F(3_B)       BS      72.00000        .               .
-54.95455   -1097.37778    1.5818e+06 F(3_A)
                                                    .               +Inf
72.00000          +Inf          +Inf

    74 t(A_Main_Tehran)
                    BS     300.00000        .               .
256.36364     -30.00000   1.65181e+06
c_u_max_market_demand_limit(Kerman_A)_
                                                    .               +Inf
600.00000        .        1.66081e+06 g(A_Tehran_Mashhad)

    75 t(A_Main_Isfahan)
                    BS    1256.36364        .               .
956.36364        .        1.66081e+06 g(A_Tehran_Mashhad)
                                                    .               +Inf
1300.00000      30.00000    1.6985e+06
c_u_max_market_demand_limit(Kerman_A)_

    76 t(B_Main_Tehran)
                    BS     511.51515        .               .
211.51515        .        1.66081e+06 g(A_Tehran_Mashhad)
                                                    .               +Inf
666.66667        .04000   1.66083e+06
c_u_transportation_limit_t(1_Tehran)_

    77 t(B_Main_Isfahan)
```

```
                     BS     155.15152        .             .          -
639.09091       -.04000   1.66081e+06
c_u_transportation_limit_t(1_Tehran)_
                                             .               +Inf
455.15152        .        1.66081e+06 g(A_Tehran_Mashhad)

    78 h(Main)       NU       1.00000        .             .
.70576        .        1.66081e+06
c_u_transportation_limit_t(Main_Isfahan)_
                                             .            1.00000
1.62303          +Inf   1.66081e+06
c_u_transportation_limit_f(Main_Tehran)_

    79 l(Tehran_Mashhad)
                     NU       1.00000        .             .
.74346  -60924.00000   1.64518e+06 c_u_discount_limit_4(1)_
                                       60924.00000       1.00000
1.18788          +Inf   1.67226e+06
c_u_max_market_demand_limit(Mashhad_B)_

    80 l(Tehran_Kerman)
                     NU       1.00000        .             .
.87173 -115998.00000   1.64593e+06 c_u_discount_limit_4(1)_
                                      115998.00000       1.00000
1.51717          +Inf    1.7208e+06 t(B_Main_Isfahan)

GLPK 5.0  - SENSITIVITY ANALYSIS REPORT
Page  20

Problem:
Objective:  revenue = 1660813.37 (MAXimum)

   No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                             Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------ ------------- ------------
    81 l(Tehran_Ahvaz)
                     NU       1.00000        .             .
.92304 -232980.00000   1.64288e+06 c_u_discount_limit_4(1)_
                                      232980.00000       1.00000
1.00000          +Inf   1.66081e+06
c_u_max_market_demand_limit(Ahvaz_B)_

    82 l(Tehran_Tabriz)
                     NU       1.00000        .             .
.91273  -91590.00000   1.65282e+06 g(B_Isfahan_Mashhad)
                                       91590.00000       1.00000
1.11273          +Inf   1.67114e+06
```

```
c_u_max_market_demand_limit(Mashhad_B)_

    83 l(Isfahan_Mashhad)
                       NU       1.00000        .              .
.89091  -82000.00000   1.65187e+06 g(B_Isfahan_Mashhad)
                                    82000.00000       1.00000
1.14091          +Inf   1.67237e+06
c_u_max_market_demand_limit(Mashhad_B)_

    84 l(Isfahan_Kerman)
                       NU       1.00000        .              .
.84607  -97500.00000   1.64581e+06 c_u_discount_limit_4(1)_
                                    97500.00000       1.00000
1.14101          +Inf   1.67456e+06 c_u_buy_from_fac_limit_t(1)_

    85 l(Isfahan_Ahvaz)
                       NU       1.00000        .              .
.84607 -117450.00000   1.64273e+06 c_u_discount_limit_4(1)_
                                   117450.00000       1.00000
1.00000          +Inf   1.66081e+06
c_u_max_market_demand_limit(Ahvaz_B)_

    86 l(Isfahan_Tabriz)
                       NU       1.00000        .              .
.95636 -185100.00000   1.65274e+06 g(B_Isfahan_Mashhad)
                                   185100.00000       1.00000
1.05636          +Inf   1.67125e+06
c_u_max_market_demand_limit(Mashhad_B)_

    87 d(1)         BS        .03079        .              .
.03079  -47849.99991   1.65934e+06 c_u_discount_limit_4(2)_
                                                      1.00000
1.03079        .        1.66081e+06 c_u_discount_limit_1(1)_

    88 d(2)         BS        .             .              .
.       -1.94999e+10   1.66081e+06 c_u_discount_limit_3(2_A)_
                                                      1.00000
.        57419.99989   1.66081e+06 c_u_discount_limit_4(2)_

End of report
```

Analysis D

here in problem D, we wanna see how much change we should make in cost of converting Ore to Alloy to stop Main fac from producing product:

Code for Analysis D

the related python code for this problem is shown below, but you should run the model_runner.py to get the result.

```
def d():
        for cost in range(300, 400):
            instance.Price_of_ore_to_alloy = cost
            solver.solve(instance)
            print(f"Price of ore to alloy:
{instance.Price_of_ore_to_alloy()}, Use Main?: {instance.h['Main']
()}")
```

Output

run the command below to see the result:

```
!python model_runner.py -d

results for problem: -d
Price of ore to alloy: 300, Use Main?: 1.0
Price of ore to alloy: 301, Use Main?: 1.0
Price of ore to alloy: 302, Use Main?: 1.0
Price of ore to alloy: 303, Use Main?: 1.0
Price of ore to alloy: 304, Use Main?: 1.0
Price of ore to alloy: 305, Use Main?: 1.0
Price of ore to alloy: 306, Use Main?: 1.0
Price of ore to alloy: 307, Use Main?: 1.0
Price of ore to alloy: 308, Use Main?: 1.0
Price of ore to alloy: 309, Use Main?: 1.0
Price of ore to alloy: 310, Use Main?: 1.0
Price of ore to alloy: 311, Use Main?: 1.0
Price of ore to alloy: 312, Use Main?: 1.0
Price of ore to alloy: 313, Use Main?: 1.0
Price of ore to alloy: 314, Use Main?: 1.0
Price of ore to alloy: 315, Use Main?: 1.0
Price of ore to alloy: 316, Use Main?: 1.0
Price of ore to alloy: 317, Use Main?: 1.0
Price of ore to alloy: 318, Use Main?: 1.0
Price of ore to alloy: 319, Use Main?: 1.0
Price of ore to alloy: 320, Use Main?: 1.0
Price of ore to alloy: 321, Use Main?: 1.0
Price of ore to alloy: 322, Use Main?: 1.0
Price of ore to alloy: 323, Use Main?: 1.0
Price of ore to alloy: 324, Use Main?: 1.0
Price of ore to alloy: 325, Use Main?: 1.0
Price of ore to alloy: 326, Use Main?: 1.0
Price of ore to alloy: 327, Use Main?: 1.0
Price of ore to alloy: 328, Use Main?: 1.0
Price of ore to alloy: 329, Use Main?: 1.0
Price of ore to alloy: 330, Use Main?: 1.0
Price of ore to alloy: 331, Use Main?: 1.0
Price of ore to alloy: 332, Use Main?: 1.0
Price of ore to alloy: 333, Use Main?: 1.0
```

```
Price of ore to alloy: 334, Use Main?: 1.0
Price of ore to alloy: 335, Use Main?: 1.0
Price of ore to alloy: 336, Use Main?: 1.0
Price of ore to alloy: 337, Use Main?: 1.0
Price of ore to alloy: 338, Use Main?: 1.0
Price of ore to alloy: 339, Use Main?: 1.0
Price of ore to alloy: 340, Use Main?: 1.0
Price of ore to alloy: 341, Use Main?: 1.0
Price of ore to alloy: 342, Use Main?: 1.0
Price of ore to alloy: 343, Use Main?: 1.0
Price of ore to alloy: 344, Use Main?: 1.0
Price of ore to alloy: 345, Use Main?: 1.0
Price of ore to alloy: 346, Use Main?: 1.0
Price of ore to alloy: 347, Use Main?: 1.0
Price of ore to alloy: 348, Use Main?: 1.0
Price of ore to alloy: 349, Use Main?: 1.0
Price of ore to alloy: 350, Use Main?: 1.0
Price of ore to alloy: 351, Use Main?: 1.0
Price of ore to alloy: 352, Use Main?: 0.0
Price of ore to alloy: 353, Use Main?: 0.0
Price of ore to alloy: 354, Use Main?: 0.0
Price of ore to alloy: 355, Use Main?: 0.0
Price of ore to alloy: 356, Use Main?: 0.0
Price of ore to alloy: 357, Use Main?: 0.0
Price of ore to alloy: 358, Use Main?: 0.0
Price of ore to alloy: 359, Use Main?: 0.0
Price of ore to alloy: 360, Use Main?: 0.0
Price of ore to alloy: 361, Use Main?: 0.0
Price of ore to alloy: 362, Use Main?: 0.0
Price of ore to alloy: 363, Use Main?: 0.0
Price of ore to alloy: 364, Use Main?: 0.0
Price of ore to alloy: 365, Use Main?: 0.0
Price of ore to alloy: 366, Use Main?: 0.0
Price of ore to alloy: 367, Use Main?: 0.0
Price of ore to alloy: 368, Use Main?: 0.0
Price of ore to alloy: 369, Use Main?: 0.0
Price of ore to alloy: 370, Use Main?: 0.0
Price of ore to alloy: 371, Use Main?: 0.0
Price of ore to alloy: 372, Use Main?: 0.0
Price of ore to alloy: 373, Use Main?: 0.0
Price of ore to alloy: 374, Use Main?: 0.0
Price of ore to alloy: 375, Use Main?: 0.0
Price of ore to alloy: 376, Use Main?: 0.0
Price of ore to alloy: 377, Use Main?: 0.0
Price of ore to alloy: 378, Use Main?: 0.0
Price of ore to alloy: 379, Use Main?: 0.0
Price of ore to alloy: 380, Use Main?: 0.0
Price of ore to alloy: 381, Use Main?: 0.0
Price of ore to alloy: 382, Use Main?: 0.0
```

```
Price of ore to alloy: 383, Use Main?: 0.0
Price of ore to alloy: 384, Use Main?: 0.0
Price of ore to alloy: 385, Use Main?: 0.0
Price of ore to alloy: 386, Use Main?: 0.0
Price of ore to alloy: 387, Use Main?: 0.0
Price of ore to alloy: 388, Use Main?: 0.0
Price of ore to alloy: 389, Use Main?: 0.0
Price of ore to alloy: 390, Use Main?: 0.0
Price of ore to alloy: 391, Use Main?: 0.0
Price of ore to alloy: 392, Use Main?: 0.0
Price of ore to alloy: 393, Use Main?: 0.0
Price of ore to alloy: 394, Use Main?: 0.0
Price of ore to alloy: 395, Use Main?: 0.0
Price of ore to alloy: 396, Use Main?: 0.0
Price of ore to alloy: 397, Use Main?: 0.0
Price of ore to alloy: 398, Use Main?: 0.0
Price of ore to alloy: 399, Use Main?: 0.0

Problem:
- Name: unknown
  Lower bound: 980595.0
  Upper bound: 980595.0
  Number of objectives: 1
  Number of constraints: 107
  Number of variables: 88
  Number of nonzeros: 342
  Sense: maximize
Solver:
- Status: ok
  Termination condition: optimal
  Statistics:
    Branch and bound:
      Number of bounded subproblems: 3
      Number of created subproblems: 3
  Error rc: 0
  Time: 0.007172584533691406
Solution:
- number of solutions: 0
  number of solutions displayed: 0

no results saved.
```

Explanation

As we see from the output, after cost of `352` the main factory will not produce any Alloy.

Analysis E

Here we wanna see how to change contract cost to see when a factory becomes unworthy to have contract with,

first we should be aware that for `Fac2`, we won't have contract in any cost, so we do analysis just for `Fac1`:

Code for Analysis E

the related python code for this problem is shown below, but you should run the model_runner.py to get the result.

```
def e():
        instance.Price_of_ore_to_alloy = 0
        for cost in range(400, 550):
            instance.contract_cost[1] = 100 * cost
            solver.solve(instance)
            print(f"Fac1 contract cost: {instance.contract_cost[1]()},
Buy from Fac1: {instance.h[1]()}, Buy from Fac2: {instance.h[2]()}")
```

Output

run the command below to see the result:

```
!python model_runner.py -e
```

```
results for problem: -e
Fac1 contract cost: 110000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 110100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 110200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 110300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 110400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 110500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 110600, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 110700, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 110800, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 110900, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111600, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111700, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111800, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 111900, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 112000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 112100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 112200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 112300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 112400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 112500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 112600, Buy from Fac1: 1.0, Buy from Fac2: 0.0
```

```
Fac1 contract cost: 112700, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 112800, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 112900, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113600, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113700, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113800, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 113900, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114600, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114700, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114800, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 114900, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115600, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115700, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115800, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 115900, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116600, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116700, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116800, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 116900, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 117000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 117100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 117200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 117300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 117400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 117500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
```

```
Fac1 contract cost: 117600, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 117700, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 117800, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 117900, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118600, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118700, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118800, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 118900, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 119000, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 119100, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 119200, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 119300, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 119400, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 119500, Buy from Fac1: 1.0, Buy from Fac2: 0.0
Fac1 contract cost: 119600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 119700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 119800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 119900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 120900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 121900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 122000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 122100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 122200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 122300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 122400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
```

```
Fac1 contract cost: 122500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 122600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 122700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 122800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 122900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 123900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 124900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 125900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 126900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 127000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 127100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 127200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 127300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
```

```
Fac1 contract cost: 127400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 127500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 127600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 127700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 127800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 127900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 128900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129000, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129100, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129200, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129300, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129400, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129500, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129600, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129700, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129800, Buy from Fac1: 0.0, Buy from Fac2: 1.0
Fac1 contract cost: 129900, Buy from Fac1: 0.0, Buy from Fac2: 1.0
no results saved.
```

Explanation

As we see, in contract cost of `119600` we won't have contract with `Fac1` and instead we will buy from `Fac2`,

if we analyzed this for `Fac2`, 'Buy from Fac2' was always 0, that is because costs of buying and sending from `Fac2` are higher.

Analysis F

Output

The part related to problem is extracted from sensit.sen:

```
  No. Column name  St      Activity      Obj coef   Lower bound
Activity      Obj coef  Obj value at Limiting
                                          Marginal   Upper bound
range         range   break point variable
------ ------------ -- ------------- ------------- -------------
------------- ------------- ------------- ------------
```

```
    22 t(A_1_Tehran)
                      NL          .          -375.00000         .
.               -Inf   1.10712e+06 R(A_1)
                                              -12.25000          +Inf
.         -362.75000   1.10712e+06 t(A_Main_Tehran)

    23 t(A_1_Isfahan)
                      NL          .          -375.00000         .
.               -Inf   1.10712e+06 R(A_1)
                                              -12.25000          +Inf
298.18182    -362.75000   1.10347e+06 g(B_Isfahan_Kerman)

    24 t(A_2_Tehran)
                      NL          .          -390.00000         .
.               -Inf   1.10712e+06 R(A_2)
                                               -7.94000          +Inf
.         -382.06000   1.10712e+06 c_u_buy_from_fac_limit_t(2)_

    25 t(A_2_Isfahan)
                      NL          .          -390.00000         .
.               -Inf   1.10712e+06 R(A_2)
                                               -7.50000          +Inf
.         -382.50000   1.10712e+06 t(B_2_Isfahan)

    26 t(B_1_Tehran)
                      BS    2034.90909    -520.00000         .
1956.60606    -520.00000   1.10712e+06
c_u_transportation_limit_t(1_Tehran)_
                                                 .               +Inf
2118.30303    -519.96000   1.10721e+06 c_u_buy_from_fac_limit_t(1)_

    27 t(B_1_Isfahan)
                      BS    1356.60606    -520.00000         .
1273.21212    -520.04000   1.10707e+06 c_u_buy_from_fac_limit_t(1)_
                                                 .               +Inf
1434.90909    -520.00000   1.10712e+06
c_u_transportation_limit_t(1_Tehran)_

    28 t(B_2_Tehran)
                      NL          .          -540.00000         .
.               -Inf   1.10712e+06 c_u_buy_from_fac_limit_f(2)_
                                                -.44000          +Inf
.         -539.56000   1.10712e+06 c_u_buy_from_fac_limit_t(2)_

    29 t(B_2_Isfahan)
                      BS          .          -540.00000         .
.         -540.44000   1.10712e+06 t(B_2_Tehran)
                                                 .               +Inf
.         -520.86400   1.10712e+06 c_u_discount_limit_4(2)_
```

Explanation

To make it clear, information showed above is related to variable t, which shows how much alloy we send to which depots in what amount(value is showed in `Activity` column).

The NL shows that variable is noneBasic, and BS shows that variable is Basic.

The `Obj coef` column shows the coefficient of that variable, it it obvious that for $t[A, F, D)$ it is equal to $priceOf\ Alloy\ Fac[A, F)$, the `Obj coef Range` shows that in what coef range the BS does not change, we will use this to determine the range of coefficients:

to buy `A` from `Fac1`: the coef range is in range (362.750 , inf) and also (362.750 , inf), so it is in range $(362.750, inf)$

to buy `A` from `Fac2`: the coef range is in range (382.060 , inf) and also (382.50 , inf), so it is in range $(382.50, inf)$

to buy `B` from `Fac1`: the coef range is in range (519.96 , 520.0) and also (520.0, 520.4), so it is in range $(520.0, 520.0)$

to buy `B` from `Fac2`: the coef range is in range (539.56 , inf) and also (520.864 , 540.44), so it is in range $(539.56, 540.44)$

but we don't want that one point range, that happens because the coefficient of B from Fac1 changes for only one Depot, this is what we don't want to happen, we want a coefficient change for both `t(B_1_Tehran)` and `t(B_1_Isfahan)`, so what we do here is in our model.lp file, we add and replace some limitations for our model, and make a new lp file called model_test.lp, here is what we change:

Modify model.lp

we replace this from Line26 to Line33 of model.lp

-375 A_1

-390 A_2

-520 B_1

-540 B_2

we add these new constraints, to have this equations: B_1 = t(B_1_Tehran)+t(B_1_Isfahan), A_1 = t(A_1_Tehran)+t(A_1_Isfahan), A_2 = t(A_2_Tehran)+t(A_2_Isfahan), B_2 = t(B_2_Tehran) +t(B_2_Isfahan)

c_u_costume_limit_B11_: +1 t(B_1_Tehran) +1 t(B_1_Isfahan) -1 B_1 <= 0

c_u_costume_limit_B12_: +1 B_1 -1 t(B_1_Tehran) -1 t(B_1_Isfahan) <= 0

c_u_costume_limit_A11_: +1 t(A_1_Tehran) +1 t(A_1_Isfahan) -1 A_1 <= 0

c_u_costume_limit_A12_: +1 A_1 -1 t(A_1_Tehran) -1 t(A_1_Isfahan) <= 0

c_u_costume_limit_A21_: +1 t(A_2_Tehran) +1 t(A_2_Isfahan) -1 A_2 <= 0

c_u_costume_limit_A22_: +1 A_2 -1 t(A_2_Tehran) -1 t(A_2_Isfahan) <= 0

c_u_costume_limit_B21_: +1 t(B_2_Tehran) +1 t(B_2_Isfahan) -1 B_2 <= 0

c_u_costume_limit_B22_: +1 B_2 -1 t(B_2_Tehran) -1 t(B_2_Isfahan) <= 0

Now, the coefficient is multiplied in both variables of the equations(for example, now, xA_1 = xt(A_1,Tehran)+ct(A_1,Isfahan)), and it changes for both!! after running the command ro make sensit.sen again, we analyze the modified output again:

```
# make sensit from modified_model.lp
!glpsol -m modified_model.lp --lp --ranges sensit.sen
```

```
GLPSOL--GLPK LP/MIP Solver 5.0
Parameter(s) specified in the command line:
 -m modified_model.lp --lp --ranges sensit.sen
Reading problem data from 'modified_model.lp'...
115 rows, 92 columns, 366 non-zeros
860 lines were read
GLPK Simplex Optimizer 5.0
115 rows, 92 columns, 366 non-zeros
Preprocessing...
107 rows, 92 columns, 348 non-zeros
Scaling...
 A: min|aij| =  5.000e-02  max|aij| =  1.000e+09  ratio =  2.000e+10
GM: min|aij| =  1.160e-01  max|aij| =  8.621e+00  ratio =  7.433e+01
EQ: min|aij| =  1.350e-02  max|aij| =  1.000e+00  ratio =  7.408e+01
Constructing initial basis...
Size of triangular part is 107
      0: obj =  -0.000000000e+00 inf =   1.586e+03 (2)
     12: obj =  -2.613400000e+05 inf =   0.000e+00 (0)
*   114: obj =   1.107124482e+06 inf =   1.997e-10 (0)
OPTIMAL LP SOLUTION FOUND
Time used:   0.0 secs
Memory used: 0.2 Mb (203989 bytes)
Write sensitivity analysis report to 'sensit.sen'...
```

Modified output

The part related to problem is extracted from sensit.sen:

```res No. Column name St Activity Obj coef Lower bound Activity Obj coef Obj value at Limiting Marginal Upper bound range range break point variable ------ ------------ -- ------------- ------------ ------------ ------------ ------------ ------------ ------------
```

```
22 A_1          BS        .         -375.00000        .               .
-Inf   1.10712e+06
                                       .                 +Inf
298.18182    -362.75000   1.10712e+06 t(A_1_Isfahan)

23 A_2          NL        .         -390.00000        .               .
```

```
-Inf   1.10712e+06 R(A_2)
                                      -7.50000          +Inf          .
-382.50000   1.10712e+06 B_2

24 B_1          BS    3391.51515    -520.00000          .
3341.44487    -520.46171   1.10556e+06 c_u_Metal_sum_limit_Z(3)_
                                        .               +Inf
3478.30424    -464.08141   1.29677e+06 c_u_Max_extracted_ore_limit(1)_

25 B_2          BS          .         -540.00000          .               .
-547.50000   1.10712e+06 A_2
                                        .               +Inf
391.51515    -520.68800   1.10712e+06 c_u_discount_limit_2(2)_
```

to buy `A` from `Fac1`: the coef range is in range (362.750 , inf) so it is in range $(362.750, inf)$

to buy `A` from `Fac2`: the coef range is in range (382.50 , inf), so it is in range $(382.50, inf)$

to buy `B` from `Fac1`: the coef range is in range (519.96 , 520.0) and also (520.0, 520.4), so it is in range $(464.08, 520.461)$

to buy `B` from `Fac2`: the coef range is in range (539.56 , inf) and also (520.864 , 540.44), so it is in range $(520.68, 547.5)$

The ranges you see above, are the allowed ranges for coefficients that don't change the Basic-Solution-Set.

Analysis G

Here we wanna see how the revenue changes by changing a coefficient and a right-hand side.

we have two parts, first we analyze the problem considering values of coefficients change separately, then we analyze the problem considering values of coefficients can change together.

in first part, we choose `depots_min_to_receive` for `Tehran` as right-hand side value and `Container_cost_to_be_sent_depot` for `MainFac` to `Tehran` as our coefficient.

in second part, For right-hand side, we chose `Max_ore` of `Fac2` and for constraint coefficient we chose `price_of_alloy_fac` for Alloy `B` in `Fac2` and plot in 3D.

Code for Analysis G

the related python code for this problem is shown below, but you should run the model_runner.py to get the result.

```python
# first part right-hand side.
def g_2():
    depot_Tehran_min_to_recieve_change_list = []
    revenue_depend_on_tehran_min_to_recieve = []

    for capacity in range(20,65):
```

```
        instance.depots_min_to_receive['Tehran'] = capacity
        solver.solve(instance)
        revenue = instance.revenue()
        print(f"Tehran minimum receive: {capacity}, Revenue
{instance.revenue()}, buy from Fac2: {instance.h[2]()}")
        revenue_depend_on_tehran_min_to_recieve.append(revenue)
        depot_Tehran_min_to_recieve_change_list.append(capacity)
    depot_Tehran_min_to_recieve_change_np =
np.array(depot_Tehran_min_to_recieve_change_list)
    revenue_depend_on_tehran_max_to_recieve_np =
np.array(revenue_depend_on_tehran_min_to_recieve)

    plt.xlabel("Tehran minimum receive")
    plt.ylabel("Revenue")
    plt.plot(depot_Tehran_min_to_recieve_change_np,
revenue_depend_on_tehran_max_to_recieve_np)
    plt.show()

#first part coefficient.
def g_3():
    Container_cost_to_be_sent_depot_list=[]
    revenue_changing_Container_cost_to_be_sent_depot_list = []

    for cost in range (100):
        new_cost =  50*cost
        instance.Container_cost_to_be_sent_depot['Main', 'Tehran'] =
new_cost
        solver.solve(instance)
        revenue = instance.revenue()
        print(f"Container cost from Main to Tehran: {new_cost},
Revenue{instance.revenue()}")
        Container_cost_to_be_sent_depot_list.append(new_cost)

revenue_changing_Container_cost_to_be_sent_depot_list.append(revenue)

    Container_cost_to_be_sent_depot_np =
np.array(Container_cost_to_be_sent_depot_list)
    revenue_changing_Container_cost_to_be_sent_depot_np =
np.array(revenue_changing_Container_cost_to_be_sent_depot_list)


    plt.plot(Container_cost_to_be_sent_depot_np,
revenue_changing_Container_cost_to_be_sent_depot_np)

    plt.xlabel("Container cost Main->Tehran")
    plt.ylabel("Revenue")
    plt.show()

#second part, both coefficient and right-hand side.
def g():
```

```
    price_of_alloy_fac_2_alloy_b_set = np.arange(0,
(instance.price_of_alloy_fac[2,'B']())*3,1)#for c
    max_ore_2_set = np.arange(0,(instance.Max_ore[2]()),100)#for b
    object =
np.zeros(shape=(len(price_of_alloy_fac_2_alloy_b_set),len(max_ore_2_se
t)))
    for i,V1 in enumerate(price_of_alloy_fac_2_alloy_b_set):
        for j,V2 in enumerate(max_ore_2_set):
            instance.price_of_alloy_fac[2,'B'] = V1
            instance.Max_ore[2] = V2
            solver.solve(instance)
            object[i,j] = instance.revenue()

    fig = go.Figure(data=[go.Surface(z=object, x=max_ore_2_set,
y=price_of_alloy_fac_2_alloy_b_set)])
    fig.update_layout(title='3D Surface Plot', autosize=True,
                      scene=dict(
                          xaxis_title='maximum of extractable ore number
2',
                          yaxis_title='price of alloy b from factory 2',
                          zaxis_title='Object'))
    fig.show()
    plt.show()#?
```

Output

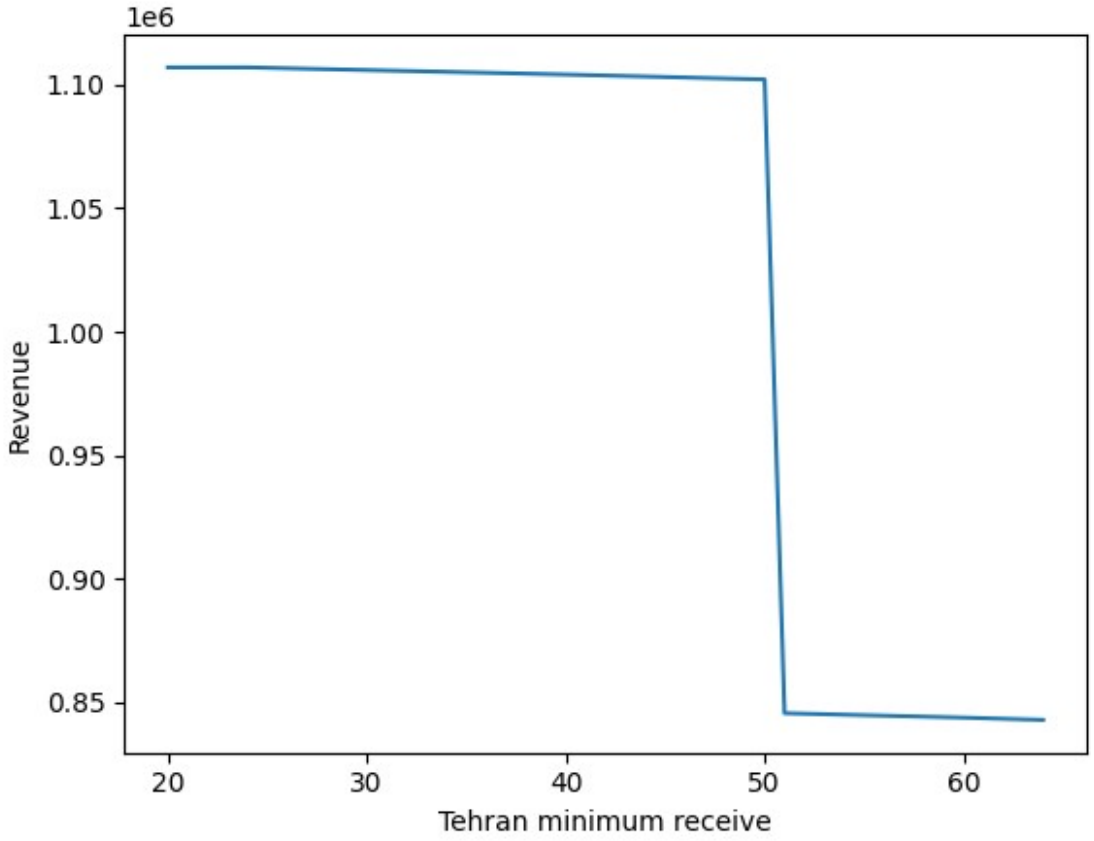
run the command below to see the result:

```
%matplotlib inline
%run model_runner.py -g

results for problem: -g
Tehran minimum receive: 20, Revenue 1107067.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 21, Revenue 1107067.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 22, Revenue 1107067.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 23, Revenue 1107067.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 24, Revenue 1107067.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 25, Revenue 1106887.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 26, Revenue 1106707.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 27, Revenue 1106527.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 28, Revenue 1106347.5757575764, buy from Fac2:
```

```
0.0
Tehran minimum receive: 29, Revenue 1106167.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 30, Revenue 1105987.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 31, Revenue 1105807.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 32, Revenue 1105627.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 33, Revenue 1105447.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 34, Revenue 1105267.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 35, Revenue 1105087.5757575766, buy from Fac2:
0.0
Tehran minimum receive: 36, Revenue 1104907.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 37, Revenue 1104727.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 38, Revenue 1104547.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 39, Revenue 1104367.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 40, Revenue 1104187.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 41, Revenue 1103987.5757575766, buy from Fac2:
0.0
Tehran minimum receive: 42, Revenue 1103787.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 43, Revenue 1103587.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 44, Revenue 1103387.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 45, Revenue 1103187.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 46, Revenue 1102987.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 47, Revenue 1102787.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 48, Revenue 1102587.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 49, Revenue 1102387.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 50, Revenue 1102187.5757575764, buy from Fac2:
0.0
Tehran minimum receive: 51, Revenue 845475.0, buy from Fac2: 1.0
Tehran minimum receive: 52, Revenue 845275.0, buy from Fac2: 1.0
Tehran minimum receive: 53, Revenue 845075.0, buy from Fac2: 1.0
Tehran minimum receive: 54, Revenue 844875.0, buy from Fac2: 1.0
```

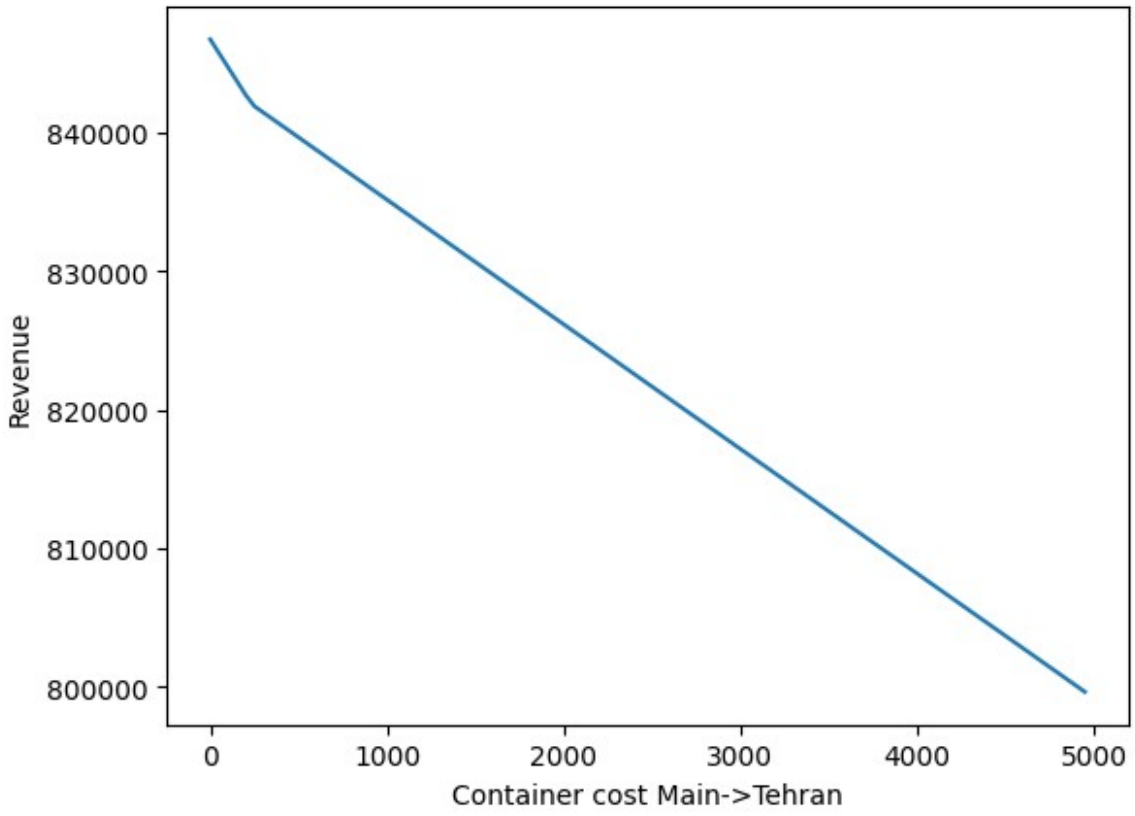
```
Tehran minimum receive: 55, Revenue 844675.0, buy from Fac2: 1.0
Tehran minimum receive: 56, Revenue 844475.0, buy from Fac2: 1.0
Tehran minimum receive: 57, Revenue 844275.0, buy from Fac2: 1.0
Tehran minimum receive: 58, Revenue 844075.0, buy from Fac2: 1.0
Tehran minimum receive: 59, Revenue 843875.0, buy from Fac2: 1.0
Tehran minimum receive: 60, Revenue 843675.0, buy from Fac2: 1.0
Tehran minimum receive: 61, Revenue 843445.0, buy from Fac2: 1.0
Tehran minimum receive: 62, Revenue 843215.0, buy from Fac2: 1.0
Tehran minimum receive: 63, Revenue 842985.0, buy from Fac2: 1.0
Tehran minimum receive: 64, Revenue 842755.0, buy from Fac2: 1.0
```




```
Container cost from Main to Tehran: 0, Revenue846755.0
Container cost from Main to Tehran: 50, Revenue845755.0
Container cost from Main to Tehran: 100, Revenue844755.0
Container cost from Main to Tehran: 150, Revenue843755.0
Container cost from Main to Tehran: 200, Revenue842755.0
Container cost from Main to Tehran: 250, Revenue841925.0
Container cost from Main to Tehran: 300, Revenue841475.0
Container cost from Main to Tehran: 350, Revenue841025.0
Container cost from Main to Tehran: 400, Revenue840575.0
Container cost from Main to Tehran: 450, Revenue840125.0
Container cost from Main to Tehran: 500, Revenue839675.0
Container cost from Main to Tehran: 550, Revenue839225.0
```

```
Container cost from Main to Tehran: 600, Revenue838775.0
Container cost from Main to Tehran: 650, Revenue838325.0
Container cost from Main to Tehran: 700, Revenue837875.0
Container cost from Main to Tehran: 750, Revenue837425.0
Container cost from Main to Tehran: 800, Revenue836975.0
Container cost from Main to Tehran: 850, Revenue836525.0
Container cost from Main to Tehran: 900, Revenue836075.0
Container cost from Main to Tehran: 950, Revenue835625.0
Container cost from Main to Tehran: 1000, Revenue835175.0
Container cost from Main to Tehran: 1050, Revenue834725.0
Container cost from Main to Tehran: 1100, Revenue834275.0
Container cost from Main to Tehran: 1150, Revenue833825.0
Container cost from Main to Tehran: 1200, Revenue833375.0
Container cost from Main to Tehran: 1250, Revenue832925.0
Container cost from Main to Tehran: 1300, Revenue832475.0
Container cost from Main to Tehran: 1350, Revenue832025.0
Container cost from Main to Tehran: 1400, Revenue831575.0
Container cost from Main to Tehran: 1450, Revenue831125.0
Container cost from Main to Tehran: 1500, Revenue830675.0
Container cost from Main to Tehran: 1550, Revenue830225.0
Container cost from Main to Tehran: 1600, Revenue829775.0
Container cost from Main to Tehran: 1650, Revenue829325.0
Container cost from Main to Tehran: 1700, Revenue828875.0
Container cost from Main to Tehran: 1750, Revenue828425.0
Container cost from Main to Tehran: 1800, Revenue827975.0
Container cost from Main to Tehran: 1850, Revenue827525.0
Container cost from Main to Tehran: 1900, Revenue827075.0
Container cost from Main to Tehran: 1950, Revenue826625.0
Container cost from Main to Tehran: 2000, Revenue826175.0
Container cost from Main to Tehran: 2050, Revenue825725.0
Container cost from Main to Tehran: 2100, Revenue825275.0
Container cost from Main to Tehran: 2150, Revenue824825.0
Container cost from Main to Tehran: 2200, Revenue824375.0
Container cost from Main to Tehran: 2250, Revenue823925.0
Container cost from Main to Tehran: 2300, Revenue823475.0
Container cost from Main to Tehran: 2350, Revenue823025.0
Container cost from Main to Tehran: 2400, Revenue822575.0
Container cost from Main to Tehran: 2450, Revenue822125.0
Container cost from Main to Tehran: 2500, Revenue821675.0
Container cost from Main to Tehran: 2550, Revenue821225.0
Container cost from Main to Tehran: 2600, Revenue820775.0
Container cost from Main to Tehran: 2650, Revenue820325.0
Container cost from Main to Tehran: 2700, Revenue819875.0
Container cost from Main to Tehran: 2750, Revenue819425.0
Container cost from Main to Tehran: 2800, Revenue818975.0
Container cost from Main to Tehran: 2850, Revenue818525.0
Container cost from Main to Tehran: 2900, Revenue818075.0
Container cost from Main to Tehran: 2950, Revenue817625.0
Container cost from Main to Tehran: 3000, Revenue817175.0
```

```
Container cost from Main to Tehran: 3050, Revenue816725.0
Container cost from Main to Tehran: 3100, Revenue816275.0
Container cost from Main to Tehran: 3150, Revenue815825.0
Container cost from Main to Tehran: 3200, Revenue815375.0
Container cost from Main to Tehran: 3250, Revenue814925.0
Container cost from Main to Tehran: 3300, Revenue814475.0
Container cost from Main to Tehran: 3350, Revenue814025.0
Container cost from Main to Tehran: 3400, Revenue813575.0
Container cost from Main to Tehran: 3450, Revenue813125.0
Container cost from Main to Tehran: 3500, Revenue812675.0
Container cost from Main to Tehran: 3550, Revenue812225.0
Container cost from Main to Tehran: 3600, Revenue811775.0
Container cost from Main to Tehran: 3650, Revenue811325.0
Container cost from Main to Tehran: 3700, Revenue810875.0
Container cost from Main to Tehran: 3750, Revenue810425.0
Container cost from Main to Tehran: 3800, Revenue809975.0
Container cost from Main to Tehran: 3850, Revenue809525.0
Container cost from Main to Tehran: 3900, Revenue809075.0
Container cost from Main to Tehran: 3950, Revenue808625.0
Container cost from Main to Tehran: 4000, Revenue808175.0
Container cost from Main to Tehran: 4050, Revenue807725.0
Container cost from Main to Tehran: 4100, Revenue807275.0
Container cost from Main to Tehran: 4150, Revenue806825.0
Container cost from Main to Tehran: 4200, Revenue806375.0
Container cost from Main to Tehran: 4250, Revenue805925.0
Container cost from Main to Tehran: 4300, Revenue805475.0
Container cost from Main to Tehran: 4350, Revenue805025.0
Container cost from Main to Tehran: 4400, Revenue804575.0
Container cost from Main to Tehran: 4450, Revenue804125.0
Container cost from Main to Tehran: 4500, Revenue803675.0
Container cost from Main to Tehran: 4550, Revenue803225.0
Container cost from Main to Tehran: 4600, Revenue802775.0
Container cost from Main to Tehran: 4650, Revenue802325.0
Container cost from Main to Tehran: 4700, Revenue801875.0
Container cost from Main to Tehran: 4750, Revenue801425.0
Container cost from Main to Tehran: 4800, Revenue800975.0
Container cost from Main to Tehran: 4850, Revenue800525.0
Container cost from Main to Tehran: 4900, Revenue800075.0
Container cost from Main to Tehran: 4950, Revenue799625.0
```




```
no results saved.

<Figure size 640x480 with 0 Axes>
```

the result for g() will be a html output in your browser, because the code takes long to generate output page, some images of output are shown below.

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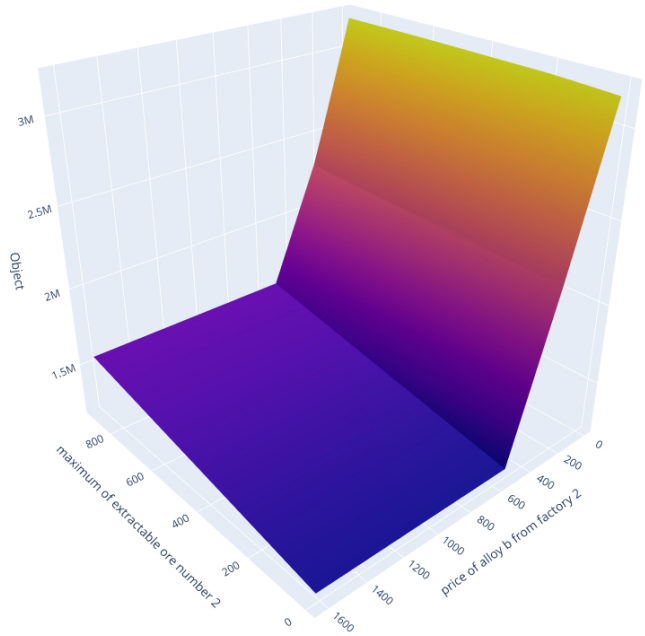
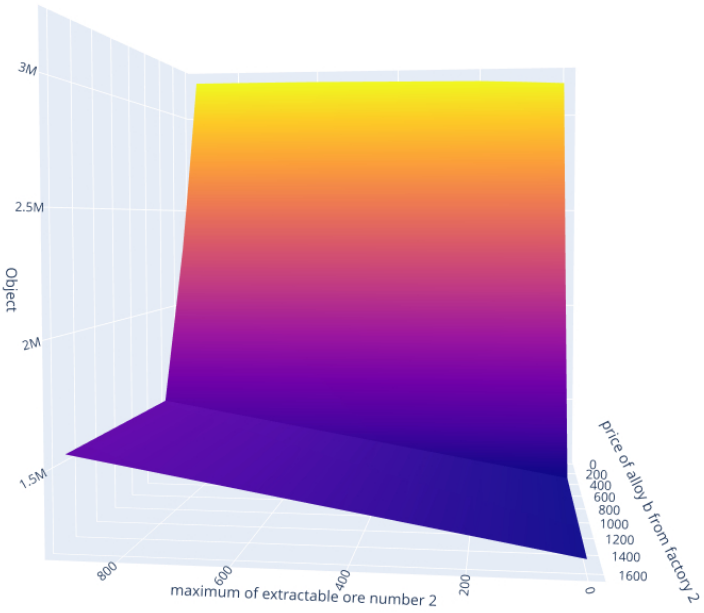
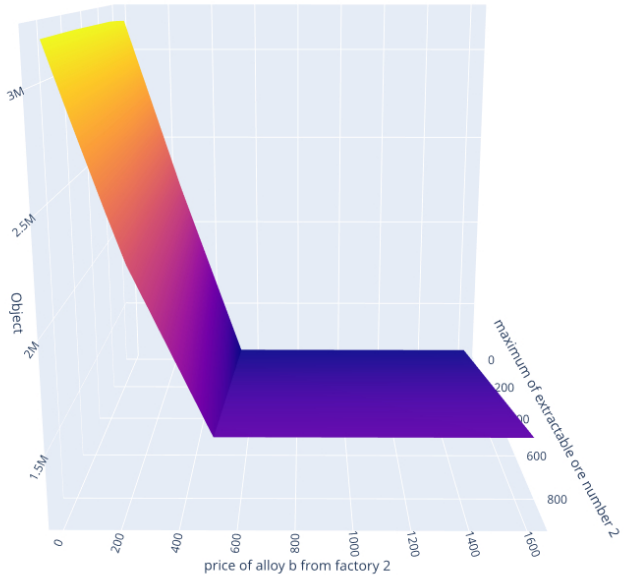






Explanation

In first output, we have revenue based on `Depot_min_to_receive` of `Tehran`, as we see, the revenue is constantly reducing, and after a point when `Fac2` enters the equation(minimum receive of 51), we will have a huge amount of reduce in revenue, which is because of having a floor of buying Alloy from `Fac2`.

In second output, we have revenue based on cost of sending container from `MainFac` to `Tehran`. as we see and as expected, as the container cost increases, the revenue decreases constantly.

In third output we see that as the `price_of_alloy_fac` for Alloy `B` in `Fac2` increases, the revenue decreases and as the `Max_ore` of `Fac2` increases, the revenue increases, which is expected.

Analysis H

we have three parts, first analyze for cost be 10 percent higher and lower.

and in second and third part we have costs range between 10 percent lower and 10 percent higher, for this parts, we chose `Container_cost_to_be_sent_depot` of `Fac1` to `Isfahan` and `Container_cost_to_be_sent_market` of `Isfahan->Mashhad` as variables, and we analyze them separately.

Code for Analysis H

the related python code for this problem is shown below, but you should run the model_runner.py to get the result.

```
def h():
    # Increase all prices
    solver.solve(instance)
    previous_revenue = instance.revenue()

    factories_list = instance.Factories()
    depots_list = instance.Depots()
    Markets_list = instance.Markets()

    for factory in factories_list:
        for depot in depots_list:
            instance.Container_cost_to_be_sent_depot[factory, depot] =
110 / 100 * instance.Container_cost_to_be_sent_depot[factory, depot]()

    for depot in depots_list:
        for market in Markets_list:
            instance.Container_cost_to_be_sent_market[depot, market] =
110 / 100 * instance.Container_cost_to_be_sent_market[depot, market]()

    solver.solve(instance)
    new_revenue = instance.revenue()
    print(f'For a 10% increase in costs, previous revenue is
{previous_revenue} and new revenue is {new_revenue}')

    # Decrease all prices
    instance = model.create_instance(data=data)
    solver.solve(instance)
    previous_revenue = instance.revenue()

    for factory in factories_list:
        for depot in depots_list:
            instance.Container_cost_to_be_sent_depot[factory, depot] =
(90 / 100) * instance.Container_cost_to_be_sent_depot[factory, depot]
()

    for depot in depots_list:
        for market in Markets_list:
```

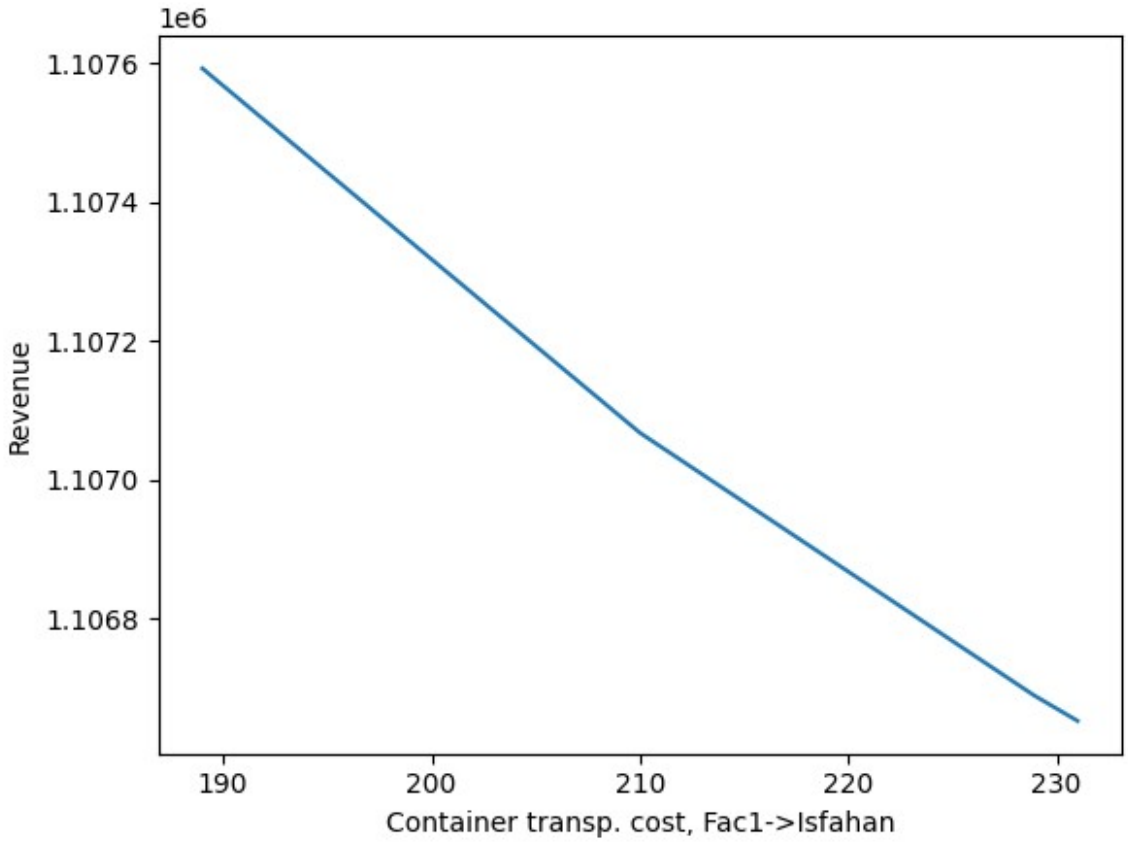
```
            instance.Container_cost_to_be_sent_market[depot, market] =
(90 / 100) * instance.Container_cost_to_be_sent_market[depot, market]
()

    solver.solve(instance)
    new_revenue = instance.revenue()
    print(f'For a 10% reduction in costs, previous revenue is
{previous_revenue} and new revenue is {new_revenue}')

def h_1():
    # Single price analysis: shipping from factory 1 to depot Isfahan
    instance = model.create_instance(data=data)
    Container_cost_to_be_sent_1_to_Isfahan = []
    revenue_changing_Container_cost_to_be_sent_1_to_Isfahan = []

    the_least_cost = instance.Container_cost_to_be_sent_depot[1,
'Isfahan']() * (90 / 100)
    cost_step = instance.Container_cost_to_be_sent_depot[1, 'Isfahan']
() / 100

    for cost in range(21):
        new_cost = cost * cost_step + the_least_cost
        instance.Container_cost_to_be_sent_depot[1, 'Isfahan'] =
new_cost
        solver.solve(instance)
        revenue = instance.revenue()
        Container_cost_to_be_sent_1_to_Isfahan.append(new_cost)

revenue_changing_Container_cost_to_be_sent_1_to_Isfahan.append(revenue
)

    Container_cost_to_be_sent_1_to_Isfahan_np =
np.array(Container_cost_to_be_sent_1_to_Isfahan)
    revenue_changing_Container_cost_to_be_sent_1_to_isfahan_np =
np.array(revenue_changing_Container_cost_to_be_sent_1_to_Isfahan)

    plt.plot(Container_cost_to_be_sent_1_to_Isfahan_np,
revenue_changing_Container_cost_to_be_sent_1_to_isfahan_np)
    plt.show()

def h_2():
    # Single price analysis: shipping from depot Isfahan to Mashhad
    instance = model.create_instance(data=data)
    Container_cost_to_be_sent_isfahan_to_mashhad = []
    revenue_changing_Container_cost_to_be_sent_isfahan_to_mashhad = []

    the_least_cost =
instance.Container_cost_to_be_sent_market['Isfahan', 'Mashhad']() *
(90 / 100)
    cost_step = instance.Container_cost_to_be_sent_market['Isfahan',
```

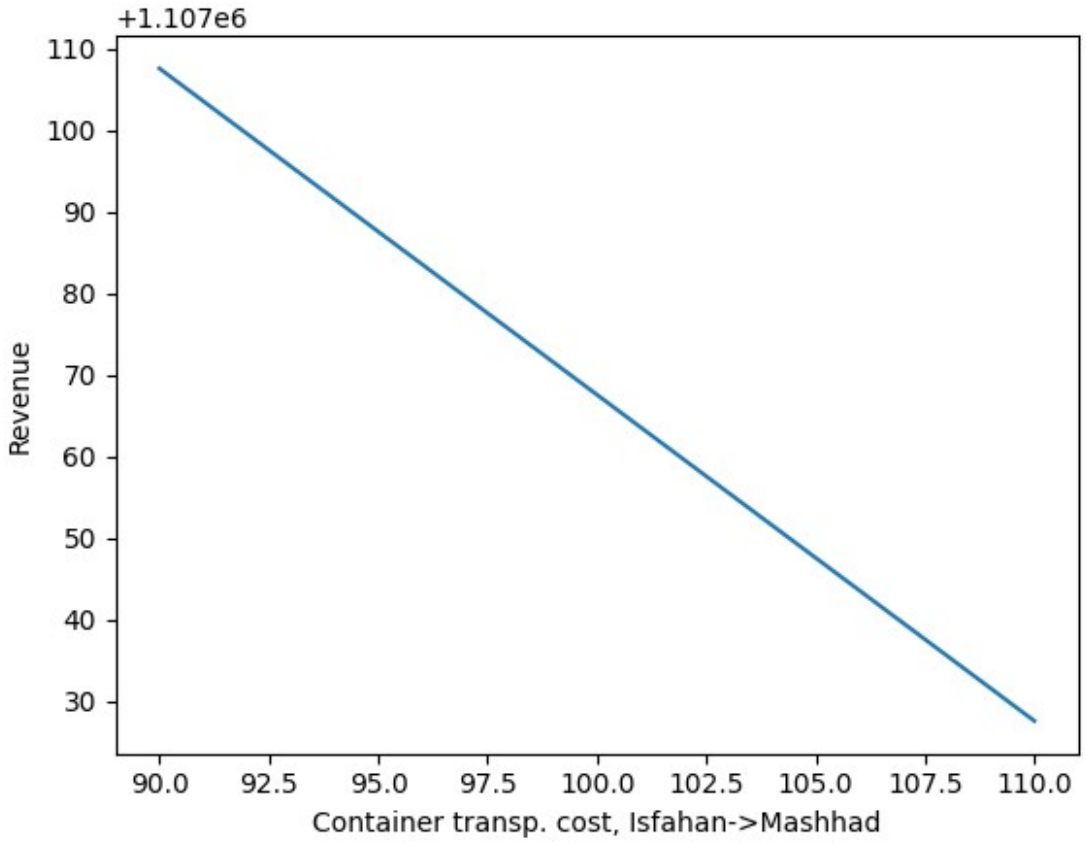
```
'Mashhad'](() / 100

    for cost in range(21):
        new_cost = cost * cost_step + the_least_cost
        instance.Container_cost_to_be_sent_market['Isfahan',
'Mashhad'] = new_cost
        solver.solve(instance)
        revenue = instance.revenue()
        Container_cost_to_be_sent_isfahan_to_mashhad.append(new_cost)

revenue_changing_Container_cost_to_be_sent_isfahan_to_mashhad.append(r
evenue)

    Container_cost_to_be_sent_Isfahan_to_mashhad_np =
np.array(Container_cost_to_be_sent_isfahan_to_mashhad)
    revenue_changing_Container_cost_to_be_sent_isfahan_to_mashhad_np =
np.array(revenue_changing_Container_cost_to_be_sent_isfahan_to_mashhad
)

    plt.plot(Container_cost_to_be_sent_Isfahan_to_mashhad_np,
revenue_changing_Container_cost_to_be_sent_isfahan_to_mashhad_np)
    plt.show()
```

Output

run the command below to see the result:

```
%matplotlib inline
%run model_runner.py -h

results for problem: -h
1107067.5757575764
For a 10% increase in costs, previous revenue is 1107067.5757575764
and new revenue is 1105486.5757575764
For a 10% reduction in costs, previous revenue is 1107067.5757575764
and new revenue is 1108648.5757575764
```


1e6
1.1076
1.1074
1.1072
1.1070
1.1068
Revenue
190
200
210
220
230
Container transp. cost, Fac1->Isfahan




```
no results saved.

<Figure size 640x480 with 0 Axes>
```

Explanation

For first part, we see that in case of cost being increased 10 percent, the `revenue` goes from `1107067.5757575764` to `1105486.5757575764`, that shows we have `1581` **less** revenue in this case.

if we decrease costs for 10 percent, the `revenue` goes from `1107067.5757575764` to `1108648.5757575764`, that shows we have made `1581` **more** revenue in this case.

For second part, in first graph we see that by increasing `Container_cost_to_be_sent_depot[1, 'Isfahan']` in the desired range, the revenue **decreases**, which is expected,

and in second graph, by increasing `Container_cost_to_be_sent_market['Isfahan', 'Mashhad']` in the desired range, the revenue **decreases**, which is expected.

Analysis I

here we wanna see after adding `Abadan` as a new `Market`, in what prices for `Alloys` `A` and `B`, it is worthy to sell Alloy in the matket.

Code for Analysis I

the related python code for this problem is shown below, but you should run the model_runner.py to get the result.

```
def i():
    print(list(instance.Markets))
    for p in range(300,500,5):
        instance.sell_prices_Abadan['A'] = p
        solver.solve(instance)
        print(f"Price of A: {p}, Sell A?
{sum(instance.Abadan_Alloys[i,'A']() for i in instance.Depots)}")
    instance.sell_prices_Abadan['A'] = 0
    for p in range(300,500,5):
        instance.sell_prices_Abadan['B'] = p
        solver.solve(instance)
        print(f"Price of B: {p}, Sell B?
{sum(instance.Abadan_Alloys[i,'B']() for i in instance.Depots)}")
```

Output

run the command below to see the result:

```
!python model_runner.py -i

results for problem: -i
for A -------------
Price of A: 300, Total sell A? 0.0
Price of A: 305, Total sell A? 0.0
Price of A: 310, Total sell A? 0.0
Price of A: 315, Total sell A? 0.0
Price of A: 320, Total sell A? 0.0
Price of A: 325, Total sell A? 0.0
Price of A: 330, Total sell A? 0.0
Price of A: 335, Total sell A? 0.0
Price of A: 340, Total sell A? 0.0
Price of A: 345, Total sell A? 0.0
Price of A: 350, Total sell A? 800.0
Price of A: 355, Total sell A? 837.857142857143
Price of A: 360, Total sell A? 2400.0
Price of A: 365, Total sell A? 2423.030303029303
Price of A: 370, Total sell A? 2423.030303029303
Price of A: 375, Total sell A? 6400.0
Price of A: 380, Total sell A? 6423.0303030293
Price of A: 385, Total sell A? 6423.0303030293
Price of A: 390, Total sell A? 6423.0303030293
Price of A: 395, Total sell A? 6423.0303030293
Price of A: 400, Total sell A? 6423.0303030293
Price of A: 405, Total sell A? 6423.030303029311
```

```
Price of A: 410, Total sell A? 6423.030303029311
Price of A: 415, Total sell A? 6423.030303029311
Price of A: 420, Total sell A? 6423.0303030293
Price of A: 425, Total sell A? 6423.030303029311
Price of A: 430, Total sell A? 6423.030303029311
Price of A: 435, Total sell A? 6423.030303029311
Price of A: 440, Total sell A? 6423.030303029311
Price of A: 445, Total sell A? 6423.030303029311
Price of A: 450, Total sell A? 6423.030303029311
Price of A: 455, Total sell A? 6423.030303029311
Price of A: 460, Total sell A? 6423.0303030293
Price of A: 465, Total sell A? 6423.030303029311
Price of A: 470, Total sell A? 6423.030303029311
Price of A: 475, Total sell A? 6423.0303030293
Price of A: 480, Total sell A? 6423.030303029311
Price of A: 485, Total sell A? 6423.0303030293
Price of A: 490, Total sell A? 6423.0303030293
Price of A: 495, Total sell A? 6423.0303030293
for B -------------
Price of B: 300, Total sell B? 0.0
Price of B: 305, Total sell B? 0.0
Price of B: 310, Total sell B? 0.0
Price of B: 315, Total sell B? 0.0
Price of B: 320, Total sell B? 0.0
Price of B: 325, Total sell B? 0.0
Price of B: 330, Total sell B? 0.0
Price of B: 335, Total sell B? 0.0
Price of B: 340, Total sell B? 0.0
Price of B: 345, Total sell B? 0.0
Price of B: 350, Total sell B? 0.0
Price of B: 355, Total sell B? 0.0
Price of B: 360, Total sell B? 0.0
Price of B: 365, Total sell B? 0.0
Price of B: 370, Total sell B? 0.0
Price of B: 375, Total sell B? 0.0
Price of B: 380, Total sell B? 0.0
Price of B: 385, Total sell B? 0.0
Price of B: 390, Total sell B? 0.0
Price of B: 395, Total sell B? 0.0
Price of B: 400, Total sell B? 0.0
Price of B: 405, Total sell B? 0.0
Price of B: 410, Total sell B? 0.0
Price of B: 415, Total sell B? 0.0
Price of B: 420, Total sell B? 0.0
Price of B: 425, Total sell B? 0.0
Price of B: 430, Total sell B? 0.0
Price of B: 435, Total sell B? 0.0
Price of B: 440, Total sell B? 0.0
Price of B: 445, Total sell B? 0.0
```

```
Price of B: 450, Total sell B? 0.0
Price of B: 455, Total sell B? 0.0
Price of B: 460, Total sell B? 0.0
Price of B: 465, Total sell B? 0.0
Price of B: 470, Total sell B? 0.0
Price of B: 475, Total sell B? 0.0
Price of B: 480, Total sell B? 0.0
Price of B: 485, Total sell B? 0.0
Price of B: 490, Total sell B? 0.0
Price of B: 495, Total sell B? 0.0
Price of B: 500, Total sell B? 2300.0
Price of B: 505, Total sell B? 2352.88888888789
Price of B: 510, Total sell B? 2352.88888888789
Price of B: 515, Total sell B? 2352.88888888789
Price of B: 520, Total sell B? 6399.999999999
Price of B: 525, Total sell B? 6400.0
Price of B: 530, Total sell B? 6400.0
Price of B: 535, Total sell B? 6423.0303030293
Price of B: 540, Total sell B? 6423.0303030293
Price of B: 545, Total sell B? 6423.0303030293
Price of B: 550, Total sell B? 6423.0303030293
Price of B: 555, Total sell B? 6423.0303030293
Price of B: 560, Total sell B? 6423.0303030293
Price of B: 565, Total sell B? 6423.0303030293
Price of B: 570, Total sell B? 6423.0303030293
Price of B: 575, Total sell B? 6423.0303030293
Price of B: 580, Total sell B? 6423.0303030293
Price of B: 585, Total sell B? 6423.0303030293
Price of B: 590, Total sell B? 6423.0303030293
Price of B: 595, Total sell B? 6423.0303030293
Price of B: 600, Total sell B? 6423.0303030293
Price of B: 605, Total sell B? 6423.0303030293
Price of B: 610, Total sell B? 6423.0303030293
Price of B: 615, Total sell B? 6423.0303030293
Price of B: 620, Total sell B? 6423.0303030293
Price of B: 625, Total sell B? 6423.0303030293
Price of B: 630, Total sell B? 6423.0303030293
Price of B: 635, Total sell B? 6423.0303030293
Price of B: 640, Total sell B? 6423.0303030293
Price of B: 645, Total sell B? 6423.0303030293
Price of B: 650, Total sell B? 6423.0303030293
Price of B: 655, Total sell B? 6423.0303030293
Price of B: 660, Total sell B? 6423.030303029311
Price of B: 665, Total sell B? 6423.0303030293
Price of B: 670, Total sell B? 6423.0303030293
Price of B: 675, Total sell B? 6423.0303030293
Price of B: 680, Total sell B? 6499.999999999
Price of B: 685, Total sell B? 6666.66666666567
Price of B: 690, Total sell B? 6700.0
```

```
Price of B: 695, Total sell B? 6966.66666666567
Price of B: 700, Total sell B? 7000.0
Price of B: 705, Total sell B? 7066.66666666567
Price of B: 710, Total sell B? 7366.66666666667
Price of B: 715, Total sell B? 8166.666666665669
Price of B: 720, Total sell B? 8166.666666665669
Price of B: 725, Total sell B? 8166.666666665669
Price of B: 730, Total sell B? 9166.66666666567
Price of B: 735, Total sell B? 9666.66666666567
Price of B: 740, Total sell B? 9666.66666666567
Price of B: 745, Total sell B? 9666.66666666567
Price of B: 750, Total sell B? 9666.66666666567
Price of B: 755, Total sell B? 9666.66666666567
Price of B: 760, Total sell B? 9666.66666666567
Price of B: 765, Total sell B? 9666.66666666567
Price of B: 770, Total sell B? 9666.66666666567
Price of B: 775, Total sell B? 9666.66666666567
Price of B: 780, Total sell B? 9666.66666666567
Price of B: 785, Total sell B? 9666.66666666567
Price of B: 790, Total sell B? 9666.66666666567
Price of B: 795, Total sell B? 9666.66666666567
no results saved.
```

Explanation

As we see, for `Alloy A` to be sold in `Abadan`, we should have a selling price above `350`,

and for `B` to be sold, we should have a price above `500`, higher price for B is because prices in other markets are higher for B, thus we should sell B in Abadan for higher price to take some share of other markets which are currently profitable.