# Project 3

December 16, 2018

Problem Description: The traveling salesperson problem (TSP1 ) asks to minimize the cost of traveling (starting from home) to a list of cities and then returning home after visiting each city once. This can be modeled as an integer programming problem with the right constraints2 . Your goal is to create your own problem, and then solve it. 1. Create a list of 5 cities (domestic or international) and a matrix that keeps track of the cost of air travel from one city to another. (The matrix should be symmetric.) You may use websites like Travelocity, etc. to estimate costs. 2. Determine a route that allows you to return home after visiting each city once at minimal cost. 3. If the airfare of the first leg of your trip goes up by 30%, how does that affect your solution? 4. Add a 6th city to your travel list. How does this affect your solution?

Objective: Minimizing the cost to travel in 5 cities.

```
In [5]: load('Shared Lin.sage')
```

```
In [6]: Cost = [0,49,82,99,96,
                74,0,44,57,71,
                17,198,0,265,534,
                107,145,28,90,32,
                76,91,90,73,80]
```

```
In [7]: var = ['AA','AB','AC','AD','AE',
               'BA','BB','BC','BD','BE',
               'CA','CB','CC','CD','CE',
               'DA','DB','DC','DD','DE',
               'EA','EB','EC','ED','EE']
```

```
In [8]: con = ['Leaving City A', 'Leaving City B','Leaving City C','Leaving City D','Leaving Ci
               'Fly into City A', 'Fly into City B','Fly into City C','Fly into City D','Fly in
               'Repeat Cities C and D']
```

```
In [9]: ob = [0,49,82,99,96,
               74,0,44,57,71,
               17,198,0,265,534,
```

```
                107,145,28,90,32,
                76,91,90,73,80]
```

```
In [10]: M = [[0,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],
              [0,0,0,0,0,1,0,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],
              [0,0,0,0,0,0,0,0,0,0,1,1,0,1,1,0,0,0,0,0,0,0,0,0,0,0],
              [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,0,1,0,0,0,0,0,0],
              [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,0],
              [0,0,0,0,0,1,0,0,0,0,1,0,0,0,0,1,0,0,0,0,1,0,0,0,0,0],
              [0,1,0,0,0,0,0,0,0,0,0,1,0,0,0,0,1,0,0,0,0,1,0,0,0,0],
              [0,0,1,0,0,0,0,1,0,0,0,0,0,0,0,0,0,1,0,0,0,0,1,0,0,0],
              [0,0,0,1,0,0,0,0,1,0,0,0,0,1,0,0,0,0,0,0,0,0,0,1,0,0],
              [0,0,0,0,1,0,0,0,0,1,0,0,0,0,1,0,0,0,0,1,0,0,0,0,0,0],
              [0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,1,0,0,0,0,0,0,0]]

In [11]: inq = [0,0,0,0,0,0,0,0,0,0,1]

In [12]: bnd = [1,1,1,1,1,1,1,1,1,1,1]

In [13]: lpBin(var, con, ob, M, inq, bnd, mx=False)

Optimal (min) value:  215.0

Variable      Value
----------  -------
AA                0
AB                1
AC                0
AD                0
AE                0
BA                0
BB                0
BC                1
BD                0
BE                0
CA                1
CB                0
CC                0
CD                0
CE                0
DA                0
DB                0
DC                0
DD                0
DE                1
EA                0
EB                0
EC                0
ED                1
```

```
EE                0

Constraint               Slack
---------------------  -------
Leaving City A               0
Leaving City B               0
Leaving City C               0
Leaving City D               0
Leaving City E               0
Fly into City A              0
Fly into City B              0
Fly into City C              0
Fly into City D              0
Fly into City E              0
Repeat Cities C and D        1
```

```
In [14]: Cost = [0,49,82,99,96,76,
                 74,0,44,57,71,89,
                 17,198,0,265,534,90,
                 107,145,28,90,32,45,
                 76,91,90,73,80,67]
         var = ['AA','AB','AC','AD','AE','AF',
                'BA','BB','BC','BD','BE','BF',
                'CA','CB','CC','CD','CE','CF',
                'DA','DB','DC','DD','DE','DF',
                'EA','EB','EC','ED','EE','EF',
                'FA','FB','FC','FD','FE','FF']
```

```
In [15]: con = ['Leaving City A', 'Leaving City B','Leaving City C','Leaving City D','Leaving C
                'Leaving City F','Fly into City A', 'Fly into City B','Fly into City C','Fly in
                'Fly into City E','Fly into City F','Repeat Cities C and D']
```

```
In [16]: ob = [0,149,82,199,96,137,   # cost of AA, AB, AC, AD, AE ,AF
                74,0,44,157,71,106,    # cost of BA, BB, BC, BD, BE, BF
                177,195,0,205,134,172, # cost of CA, CB, CC, CD, CE, CF
                197,155,22,0,152,310,  # cost of DA, DB, DC, DD, DE, DF
                96,101,67,153,0,82,    # cost of EA, EB, EC, ED, EE, EF
                137,106,39,311,82,0]
```

```
In [17]: M = [[0,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],
               [0,0,0,0,0,0,1,0,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],
               [0,0,0,0,0,0,0,0,0,0,0,0,1,1,0,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0],
               [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,0,1,1,0,0,0,0,0,0,0,0,0,0],
               [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,0,1,0,0,0,0],
               [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1],
               [0,0,0,0,0,1,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0],
               [0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0],
               [0,0,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0],
```

```
              [0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,1,0,0],
              [0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,1,0],
              [0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,1,0,0,0,0,0,0],
              [0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,]]
```

```
In [18]: inq = [0,0,0,0,0,0,0,0,0,0,0,0,1]
```

```
In [19]: bnd = [1,1,1,1,1,1,1,1,1,1,1,1,1]
```

```
In [20]: lpBin(var,con,ob,M,inq,bnd,mx=False)
```

```
Optimal (min) value:  617.0

Variable      Value
----------  -------
AA                0
AB                0
AC                0
AD                1
AE                0
AF                0
BA                1
BB                0
BC                0
BD                0
BE                0
BF                0
CA                0
CB                0
CC                0
CD                0
CE                1
CF                0
DA                0
DB                0
DC                1
DD                0
DE                0
DF                0
EA                0
EB                0
EC                0
ED                0
EE                0
EF                1
FA                0
FB                1
FC                0
FD                0
```

```
FE                0
FF                0

Constraint               Slack
---------------------  -------
Leaving City A               0
Leaving City B               0
Leaving City C               0
Leaving City D               0
Leaving City E               0
Leaving City F               0
Fly into City A              0
Fly into City B              0
Fly into City C              0
Fly into City D              0
Fly into City E              0
Fly into City F              0
Repeat Cities C and D        0
```

In [0]:

In [0]: