Linear Program Optimization

Data Processing

The situation for this problem required the optimal daily diet to be determined to meet the nutritional requirements of soldiers in the Army during the 1930's and 40's, while also minimizing the total cost of the food required for this diet.

To begin, the nutritional data, minimum and maximum nutritional requirements, nutritional data, and list of possible foods were processed.

```python
# Process Data
## minimum and maximum amounts
mins = diet.iloc[65][3:].values
maxs = diet.iloc[66][3:].values

## df containing only food data
food_data = diet[0:64]
## dictionary of foods & nutrition
food_dict = food_data.set_index('Foods').T.to_dict()
## list of foods
food_list = list(food_dict.keys())
```

Optimization Framework

Next, the optimization framework was created along with the necessary variables and objective function. The goal of this optimization problem was to minimize the total cost of the diet, and the variables needed were the foods chosen, and how much they were part of the diet.

```python
# Set Up Optimization
## create optimization framework (minimization)
problem = LpProblem('Diet Problem', LpMinimize)
## create variables
food_var = LpVariable.dicts('Food', food_list, lowBound = 0)
chosen_var = LpVariable.dicts('Chosen', food_list, cat = 'Binary')
## create objective function
problem += lpSum([food_dict[food]['Price/ Serving'] * food_var[food] for food
in food_list]), 'Total Cost'
```

Constraints

Afterwards, the constraints for this optimization problem needed to be added.

The first constraint needed was a requirement of a minimum of 0.1 servings of any food chosen. A maximum was also needed in this case, which was set at 100 servings.

```python
# minimum of 1/10 serving, maximum of 100 servings
for food in food_list:
    problem += food_var[food] >= 0.1 * chosen_var[food]
    problem += food_var[food] <= 100 * chosen_var[food]
```

To make for a more enjoyable diet, a constraint was added so that no more than 1 total serving of Frozen Broccoli and Raw Celery could be included in the optimal diet. This was chosen because these are known healthy and cheap foods, but are also commonly disliked by consumers.

```python
# limit Frozen Broccoli & Celery
problem += chosen_var['Frozen Broccoli'] + chosen_var['Celery, Raw'] <= 1,
'Limit Bad Foods'
```

The next constraint was to include a variety of protein in the optimal diet. A minimum of three different types of protein were chosen.

```python
# variety of protein
problem += chosen_var['Tofu'] + chosen_var['Roasted Chicken'] +
chosen_var['Poached Eggs'] + \
    chosen_var['Scrambled Eggs'] + chosen_var['Bologna,Turkey'] +
chosen_var['Frankfurter, Beef'] + \
    chosen_var['Ham,Sliced,Extralean'] + chosen_var['Kielbasa,Prk'] +
chosen_var['Hamburger W/Toppings'] + \
    chosen_var['Hotdog, Plain'] + chosen_var['Pork'] + chosen_var['Sardines
in Oil'] + chosen_var['White Tuna in Water'] >= 3, 'Three Protein Minimum'
```

Finally, the minimum and maximum nutrition requirements were included for Calories, Cholesterol, Total Fat, Sodium, Carbohydrate, Dietary Fiber, Protein, Vitamin A, Vitamin C, Calcium, and Iron.

```python
# min & max nutrient requirement
for i, nutr in enumerate(list(food_dict['Frozen Broccoli'].keys())[2:]):
    nutrients = lpSum([food_var[food] * food_dict[food][nutr] for food in
food_list])
    problem += nutrients >= mins[i]
    problem += nutrients <= maxs[i]
```

Solution

Lastly, the optimization solution was computed. Below, the optimal diet and cost can be seen.

```python
# Solve Optimization
## Solve
```

```python
problem.solve()
## Print Results
print('Optimal Diet:')
for var in problem.variables():
    if var.varValue > 0:
        if str(var).find('Chosen'):
            print('{:.2f}'.format(round(var.varValue,2)) + " servings of " +
str(var)[5:])

# print the costs of the optimal diet
print("Total Cost of Diet = $%.2f" % value(problem.objective))
```

```
Optimal Diet:
42.40 units of Celery,_Raw
0.10 units of Kielbasa,Prk
82.80 units of Lettuce,Iceberg,Raw
3.08 units of Oranges
1.94 units of Peanut_Butter
0.10 units of Poached_Eggs
13.22 units of Popcorn,Air_Popped
0.10 units of Scrambled_Eggs
Total Cost of Diet = $4.51
```

This might not be the most enjoyable diet, but it is a cost effective one! Further improvements could be made to increase the variety of the diet selected to balance nutrition and cost with perceived enjoyment of eating the meal.