Diet Optimization Problem

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Francesca Ferrero, Emilie Hsieh, Ariel Wagner

Introduction

In the United States, diet is a huge problem for everyone with the obesity rate rising rapidly every year. It's especially hard for lower income people to eat a healthy diet at a reasonable price. With healthy and organic foods being sold at higher end stores like Whole Foods for much higher prices, people are forced to resort to fast food and more processed food that is within their price range. It is much harder to put together a healthy, appetizing diet at a low price because the most nutritious foods that are sold at cheap prices may not be very appealing. There are many unhealthy foods that are cheap and extremely appealing to peoples' appetites, for example chips, cookies, fast food, just to name a few. It is much easier and much more appealing for someone to buy and eat cheap, unhealthy food because they can't afford better. Our goal is to construct a healthy and balanced diet at the lowest price possible.

Optimization Problem

In order to find a low-price yet still healthy diet, we wanted to compare the prices of foods as well as their nutritional value. This way we can construct an optimization problem that will minimize price while maximizing nutritional value. Using the recommended daily intake taken from the FDA, we put together a diet that meets the recommended values while still keeping the price down. In order to do this, we focused on the major food groups –grains, vegetables, fruits, dairy, meat, fats, and calories. These intakes can be seen in Appendix A. Using this information, we then looked up the nutritional values of various foods in these different groups as well as their prices. This information was found on peapod.com and can be seen in the attached excel spreadsheet. The optimization problem for this can be seen in Appendix B. After first finding the cheapest meal with the greatest nutritional value, we added calories as another dimension. As well as minimizing price, we wanted to find other meal options with low calorie intake. The caloric intakes of all the foods can also be seen in the attached excel spreadsheet. Not only did we aim to find meals with low caloric intake, but we also wanted to find lots of different potential meals with various types of food in them. Our goal here was to have variety. We altered the standard deviation of the serving sizes in order to achieve variety for the meals. This is only one method of doing this problem but there are many other ways as well. The solution to this problem can be seen in the attached excel spreadsheet and the optimization problem can be seen in Appendix B.

Conclusion

For the first part of our problem, we were able to input all the data about the caloric intake, price, and nutritional value, and find a nutritional meal at the lowest possible price. This meal consists of 12 slices of white bread, 1.25 cups of cabbage, 1.25 cups of sweet potatoes, 2 apples, 3 cups of 2% milk, 4.8 ounces of chicken thighs, 0.7 ounces of chicken drumsticks, 2 tablespoons of margarine, and 2.33 ounces of Skittles. This clearly is a very strange meal but it will satisfy the daily recommended intake of all the food groups. In the second part of the problem we aimed to find more variety and more meal options that are just as cheap and low in calories. In Appendix C, you can see a graph of the number of items versus the price. It is obvious that the meals with the most variety are the most expensive. Here, there is clearly a tradeoff here between variety and price. In conclusion, the most basic meal will satisfy the recommended daily intake for a low price, but if you crave more variety in your meals there will be an extra cost.

Appendix A. Recommended Daily Intake

Grains	1 ounce
Vegetables	2.5 cups
Fruits	2 cups
Dairy	3 cups
Meat	5.5 ounces
Fats	6 tsp
Calories	265 calories

Appendix B. Optimization Problems

Part a:

$$\min \sum_{i}^{n} c_i x_i$$

$$\text{s.t.} \quad x_i \geq 0$$

$$\sum_{\text{grains}} x_i = 6$$

$$\sum_{\text{vegetables}} x_i = 2.5$$

$$\sum_{\text{fruits}} x_i = 2$$

$$\sum_{\text{meats}} x_i = 5.5$$

$$\sum_{\text{fats}} x_i = 2$$

$$\sum_{\text{discrectionary}} x_i = 265$$

$$\sum_{i}^{n} k_i x_i = 2000$$

$$\sum_{i}^{n} f_i x_i \leq 0.3 \sum_{i}^{n} k_i x_i$$

where n is the total number of items, c_i is the cost per serving size of item i, x_i is the number of servings of item i, k_i is the number of calories per serving size of item i and f_i is the number of calories from fat per serving size of item i.

Part b:

$$\min \sum_{i}^{n} c_i x_i$$

s.t. $x_i \geq 0$

$$\sum_{\text{grains}} x_i = 6$$

$$\sum_{\text{vegetables}} x_i = 2.5$$

$$\sum_{\text{fruits}} x_i = 2$$

$$\sum_{\text{meats}} x_i = 5.5$$

$$\sum_{\text{fats}} x_i = 2$$

$$\sum_{\text{discrectionary}} x_i = 265$$

$$\sum_{i}^{n} k_i x_i = 2000$$

$$\sum_{i}^{n} f_i x_i \leq 0.3 \sum_{i}^{n} k_i x_i$$

$$\sqrt{\frac{1}{n} \sum_{i}^{n} \left(x_i - \bar{x}\right)^2} \leq \{0.35, 0.4, 0.45 \ldots 1.15\}$$

$$\bar{x} = \frac{1}{n} \sum_{i}^{n} x_i$$

where n is the total number of items, c_i is the cost per serving size of item i, x_i is the number of servings of item i, k_i is the number of calories per serving size of item i and f_i is the number of calories from fat per serving size of item i.

Appendix C. Graph of number of items vs. price