

# Diet problem and the method linear programming

Jingyuan Zheng\*

Department of mathematics, UC Santa Barbara Santa Barbara, CA 93106, United States

\* Corresponding Author Email: jingyuanzheng@ucsb.edu

**Abstract.** Nutrition is very important to people, and they need enough nutrition to support their body and life. The diet problem's purpose is to find a set of foods that will meet a set of daily nutritional requirements for the least amount of money. The issue is presented as a linear program, with the goal of minimizing costs and the restrictions of meeting the required nutritional needs. Dietary restrictions usually limit the number of calories consumed as well as the number of vitamins, minerals, fats, salt, and cholesterol consumed. While the mathematical formula is straightforward, the answer may not be. The nutritional requirements may be reached regardless of flavor or diversity, so think about the outcome before diving into a meal from a "ideal" menu! In this paper, a detailed summary on linear programming and associated diet problem are presented.

**Keywords:** Diet problem; linear programming; nutrition; dietary restriction; calories.

## 1. Introduction

Nutrition is significant in people's life because they support our body every day. However, the people who live in the poor area, may not have enough money to buy enough food or supplements to get enough nutrition for their bodies. Therefore, I want to do research to help these people how to use as little money as possible to get enough nutrition for their bodies. This research has the difficult part to start at first hand. The reason why this research is difficult to start at first is that the cost of food and supplements is different by country and state. In order to solve this problem, I need to collect the data of cost from different countries and states and then generalize the average data in order to start my calculations. The other problem is that people's financial ability and the money that they can use to pay are also different by country and state. I use a similar solution to solve this problem. I choose the bottom thirty percent annual income of the world as the money and finance data in my research paper. The way I'm going to start this research is that I am going to use the linear program to do the research. I am going to use the linear program and find their minimum and maximum in the graph and calculate the money that they are going to use in their product. I am going to create the objective function and the feasible set. The reason why this research is difficult to start at first is that the cost of food and supplements is different by country and state. In order to solve this problem, I need to collect the data of cost from different countries and states and then generalize the average data in order to start my calculations. The other problem is that people's financial ability and the money that they can use to pay are also different by country and state. I use a similar solution to solve this problem. I choose the bottom thirty percent annual income of the world as the money and finance data in my research paper. The way I'm going to start this research is that I am going to use the linear program to do the research. I am going to use the And I will also graph the function in the graph and then find the subject and the maximize in the graph to get the value that I want to have. However, this research may also have some limitations. The reason why this research has some limitations is that the data and the value that I choose is the average value. Hence, it may not apply to people in every corner of this world. In this paper, I am going to show the data that I collect and the main work and calculations that I do for this paper. And I will also show the conclusion for this paper and the reference that I use. In the future, I may also use the same method to do the research on the farm. For example, what is the most effective way for farmers to use minimum cost for the diet that they use for the animals that they have to feed. And I can also apply these methods to the border field in the future. program and find their minimum and

maximum in the graph and calculate the money that they are going to use in their product. I am going to create the objective function and the feasible set.

## 2. Main Part

### 2.1. Diet Problem

The goal of the diet issue is to choose the number of servings of each item to purchase (and consume) according to the cost per serving of each meal and the nutrient information for each food. For each dietary component, the nutritional needs are usually given as a minimum and maximum permissible amount. Other restrictions, such as a minimum and/or a maximum number of servings, may be added to improve the menu's quality. With the least number of adjustments, linear programming (LP) may be used to address concerns of matching diets to nutritional and other extra limitations. Linear programming is a mathematical approach for finding optimal solutions that meet several constraints at the same time. Between 1950 and 1960, the first research using LP in diets was published. Jerry Cornfield, who created "The Diet Problem" for the Military during World War II (1941–1945) in quest of a minimal diet that would fulfill a soldier's nutritional demands, initiated the hunt for diet solutions [1-20]. George Stigler, an economist, experimented with optimization techniques to find the cheapest diet that provided enough energy, proteins, vitamins, and minerals [1-20]. This diet, according to Buttriss et al., should be made up of 77 US items whose prices and nutritional content have been determined: "Stigler was unable to develop an accurate solution to this problem, which proved to be extremely difficult. The Stigler "Diet Problem" is a classic resource optimization problem, or, in mathematical words, the minimization of a linear function responsive to numerous given constraints, also known as linear programming. The Air Force and other sectors of the army hired mathematicians to address the essential diet problem and design economical meals throughout World War II. George Dantzig was one of the researchers that worked on this subject. He presented a novel algorithm that he had created. It took him until 1947 to produce the proper mathematical conclusion, and he was the first to do it. Dantzig put his approach to the test on his diet, compiling a database of 50 items [21-24]. This diet, according to Buttriss et al., should be made up of 77 US items whose prices and nutritional content have been determined: "Stigler was unable to develop an accurate solution to this problem, which proved to be extremely difficult. The Stigler "Diet Problem" is a classic resource optimization problem, or, in mathematical words, the minimization of a linear function responsive to numerous given constraints, also known as linear programming. The Air Force and other sectors of the army hired mathematicians to address the essential diet problem and design economical meals throughout World War II. George Dantzig was one of the researchers that worked on this subject. He presented a novel algorithm that he had created. It took him until 1947 to produce the proper mathematical conclusion, and he was the first to do it. Dantzig put his approach to the He set an aim function to optimize the sense of being full in order to lower his calorie intake to 1,500 kcal (operationalized as the weight per unit minus the weight of its water content). He discovered a remedy in a strange diet consisting of 200 bouillon cubes each day. This was achievable since the previous nutritional criteria did not include a salt limit. As a result of these findings, upper boundaries were established. Cornfield, a mathematician, began his search for solutions to the Diet Problem by creating an Input-Output model. Hoffenberg, a coworker, recommended utilizing the simplex approach (a standard method of maximizing a linear function of several variables). By using the simplex technique, a group required 120 man to come up with solutions in 1947. Dantzig presented a linear program and began utilizing an IBM 701 machine in the 1950s a few years later. Diet solutions were heavily reliant on the advancement of computer technology with great calculating capabilities. The moment when fast computer technology was accessible made the arduous computations required for LP practicable. on his diet, compiling a database of 50 items. Many people have created and solved diet issues attempting to mimic or enhance Stigler's fundamental framework throughout the years. Every scientist contributes stuff new to the table, whether it's revised pricing, revised RDA values, and adjusted dietary

nutritional content. Some of these are detailed by Smith (1963), who refers to them as "primarily nutritious systems" since their purpose is to be as cheap as feasible while yet satisfying caloric and nutrient standards (the same goal as Stigler's model) [1-25]. It is challenging to create acceptable diets by just mixing individual items with this basic goal. Shortly after Stigler's menu was integrated using linear programming, methods like choosing and sub-optimizing by food categories, bounding quantities from above and below, and employing preference weights were suggested and tried. Next, we'll look at two such research. One of Smith's dietary difficulties featured 13 limits, comprising upper and bottom boundaries on caloric intake and high carbohydrate consumption. For the nutritional composition of 73 items, he utilized a government guidebook as a reference. These were the items that 176 households in the Lansing, Michigan region ate on a regular basis in 1955[1-25]. These food costs were averaged across all of the families polled. The RDAs were calculated for a group of family 45-year-old adults and their 18-year-old daughter who are healthy, athletic, and live in a moderate environment [1-25]. Beckmann (1960) proposes a method and solution based on the same nine minerals as Stigler, albeit with RDA levels revised to 1958. He utilized another unique set of foodstuffs and resources for the nutritional content, with food costs as they were in the fall of 1959 in Providence, Rhode Island. He addressed two issues for a 45-year-old male, one at a 3000-calorie level and another at a 2200-calorie level, both for a 45-year-old male. The paper written by Anderson and Earle uses linear programming and goal programming to find a diet plan among 150 foods to meet Thais' daily specific nutritional requirements [25]. However, this method would lead to an oversupply of certain nutrients. It is challenging to achieve this goal because of the complex relationship among constraints in linear programming. Therefore, scientists choose the modified linear programming, an approach to achieve nutritional balance in selected diets, to compensate for the shortcomings of linear programming. Most of the diet problems focus more on the balance of the cost and nutrition. In 2010, the Food and Agriculture Organization of the United Nations (FAO) set specifications for sustainable food. In 2018, Corné van Dooren used this as a background to detailly interpret how to solve the diet problem by the method of linear programming with the addition of the economic and environmental components and give a review of the aim, history, and calculation method in his problem [26 -28].

## 2.2. Linear Programming

The linear Programming model can be written as following forms:

Form 1:

Optimized function:

$$\max \mu_p = \sum_{i=1}^n x_i \mu_i \tag{1}$$

Additional conditions:

$$\sum_{i=1}^N \sum_{j=1}^N x_i x_j \sigma_i \sigma_j \rho_{ij} \leq \sigma \tag{2}$$

Where  $\sigma$  is a given constant

$$\sum_{i=1}^n x_i = 1 \tag{3}$$

Form 2:

Optimized function:

$$\min \sigma_p^2 = \sum_{i=1}^N \sum_{j=1}^N x_i x_j \sigma_i \sigma_j \rho_{ij} \tag{4}$$

Additional conditions:

$$\sum_{i=1}^n x_i \mu_i \geq \mu \tag{5}$$

Where  $\mu$  is a given constant.

$$\sum_{i=1}^n x_i = 1 \tag{6}$$

The objective function is the function that is maximized. Functional constraints are the inequalities listed below. The last limitation specifies that  $x$  must be a non-negative number. With those limitations, we'll receive the maximum value of the objective function and the matching value  $x$ , which we'll name viable solutions. There is a chance that linear programming will provide an infeasible solution, meaning that no solution can be discovered that meets all of the constraints. The requirement to address complicated planning issues in wartime operations prompted the development of linear programming as a field in the 1940s. Its growth developed significantly in the postwar period, as numerous businesses discovered that linear programming had practical applications. George B. Dantzig, who invented the simplex technique in 1947, and John von Neumann, who founded the concept of dualism the same year, are widely considered as the subject's pioneers [25-26]. The Nobel Prize in Economics was given to the mathematician Leonid Kantorovich (USSR) and the economist Tjalling Koopmans (USA) in 1975 for their theoretical explanations of optimum resource allocation, in which linear programming played an important part [25-26]. Many sectors utilize simplex method as a typical method, for example, to effectively allocate a restricted set of resources. Airline crew scheduling, transportation or telecommunications networks, oil refineries and blending are only a few examples of key application fields. Since the 1940s, the simplex approach has been the dominant way of resolving linear programs [25-26]. In a nutshell, the simplex technique moves through vertex to vertex on the conceivable polyhedron's border, raising the optimal solution continuously until either a best solution is discovered or no solution is obtained. In theory, the time required may be exponential measure of variables. In reality, however, the approach is extremely efficient, requiring just a number of steps compared to the number of variables. On computer system, linear problems with hundreds or even thousands of variables are frequently performed using the simplex approach. A solution is any set of values for the decision variables ( $X_1, X_2, \dots, X_n$ ) that does not indicate the final solution to the issue. All of the restrictions are satisfied by a reasonable solution. An impractical solution, on the other hand, breaches at least one requirement. All potential solutions make up the feasible area. A problem may not have a viable solution because the accompanying limitations may eliminate the feasible region. As a result, the new product combination will not outperform the current one. Linear programming seeks to discover the best feasible solution given a set of viable options, as assessed by the value of the objective function in the model. With the most favorable goal function value, the optimal solution is possible. Linear programming seeks to discover the best feasible solution given a set of viable options, as assessed by the value of the objective function in the model. With the most favorable goal function value, the optimal solution is possible. The most advantageous value is the greatest value when the objective function reaches its maximum value. It is the minimum when the goal function is minimized. In most cases, there is just one best answer. There may, however, be more than one. A corner viable (CPF) solution is one that is found at the intersection of two viable areas. Consider any linear programming problem with bounded feasible areas and viable solutions. Consider any linear programming problem with bounded feasible areas and viable solutions. There must be a CPF solution and at least one optimum solution for the problem. Furthermore, the finest CPF solution must be the greatest. As a result, if there is only one optimal solution to a problem, it must be a CPF solution. If there are several optimum solutions to a problem, at least two of them must be CPF solutions.

### 3. Conclusion

LP might be useful in assisting in the creation of dietary guidelines that meet all nutritional needs. LP has proved to be a useful method for converting established nutritional limitations into diets with random meal combinations. Most studies have employed nutritional and cost restrictions to analyze dietary issues and solutions, however these studies start to exhibit flaws when there are a limited number of food products and/or nutritional limits. Although it is advised that acceptability limitations be introduced, no study has yet revealed the final method to calculate suitability.

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