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Economic Analysis of Options for Food Aid Policy in Honduras

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Abstract

This research uses data from a nutrition program implemented by Land O' Lakes International Agriculture division through the U.S. Agency for International Development and funded by the Millennium Challenge Account. The combination of foods in this program includes a tortilla, cheese, and milk. The United Nations World Food Programme provides rice and beans in Honduras. The two programs (and their combination) serve as a basis for better understanding the mix of foods in a low cost diet and the food policy options for food aid in Honduras. This research is of interest to managers of agricultural and food firms since they are heavily involved in the supply chain for distribution of US food aid.

Keywords: economics, food policy, Latin America, nutrition

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Introduction

The purpose of this research was to formulate an analysis of alternative food diets for three different family income levels based on four types of schools located in Honduras. Personal interviews were conducted with children, parents, and teachers over the course of two summers. A linear programming model was used to evaluate the economic and nutritional feasibility of four policy options.

The policy options included the provision of milk; a provision of a multi-nutrient bar; a combination of a multi-nutrient bar and milk; and a nutritionally complete diet. All four of these policies increase the supply of nutritious food for children who attend schools. The economic impact was found to be greatest in rural areas using a targeted approach to identify the poorest while working cooperatively with the parents in a nutrition education program.

Background

Between 1960 to 2003, Gardner (2000) shows that Honduras had the second lowest Gross Domestic Product (GDP) relative to 11 other Latin American countries. The United Nations World Food Programme (UNWFP) and United States Agency for International Development (USAID) work through schools to improve nutrition. The objective is to formulate an analysis of alternative food diets for an average Honduran child for three different family income levels based on four types of school locations. The results are used to develop and analyze the feasibility of four policy options available for food aid in Honduras. They include the implementation of school nutrition programs. The first policy option is the provision of ultra-high temperature (UHT) milk ("milk") in the diet. The second policy option is the provision of a multi-nutrient bar. The third policy option is to provide a provision of a multi-nutrient bar and milk. The fourth policy option is the provision of a nutritionally complete diet. All four policies increase food supply and more importantly, increase the supply of nutritious food. Thus, these programs should also help reduce poverty as suggested by Smith and Haddad (2001) and improve Honduras' relatively low agricultural productivity as noted by Gardner (2000).

The research uses data from a nutrition program implemented by Land O' Lakes International Agriculture division through the USAID and funded by the Millennium Challenge Account which is managed by the Millennium Challenge Corporation. The combination of foods in this program includes a tortilla, cheese, and milk and is referred to as the School Nutrition Program (SNP). The UNWFP provides rice and beans in Honduras. The two programs (and their combination) serve as a basis for better understanding the mix of foods in a low cost diet and the food policy options for food aid in Honduras. This research is of interest to managers of agricultural and food firms since they are heavily involved in the supply chain for distribution of U.S. food aid. There was recently a large debate in the United States Congress over the role of U.S. food aid programs. U.S. food aid to Honduras was over $40 million in 2008.

Methodology

Figure 1 is a diagram of the methodology used in this research which has been used by the U.S. Department of Agriculture and other organizations in conducting similar research. The food must

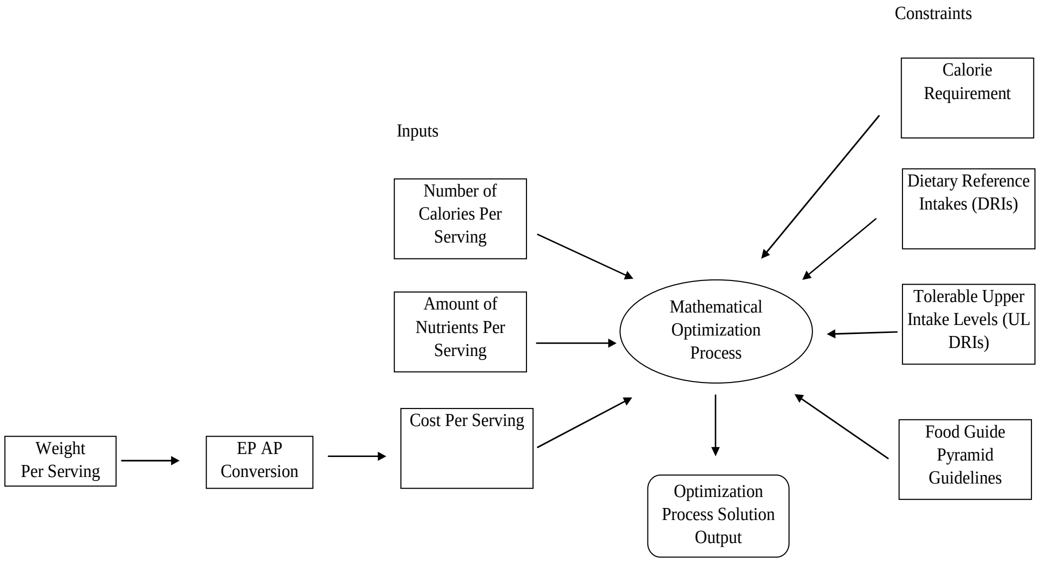

Figure 1. Overview of the methodology used in the model

first be measured into appropriate serving sizes. Then, each serving is weighed in order to know the exact number of grams per serving. A conversion must be used to convert the "as purchased" (AP) weight into "edible portion" (EP) weight. Then it is possible to calculate an accurate cost per serving using these weights. The number of calories and amount of nutrients per serving are provided by the U.S. Department of Agriculture (2006) Nutrient Data Laboratory. The constraints on the model are the dietary reference intakes (DRIs) for calories and nutrients, maximum limits on these nutrients, and the Food Guide Pyramid guidelines.[1] The optimization model generates a solution using these inputs, while meeting the constraints.

The objective function is designed to determine the least cost of a nutritionally adequate human diet. Constraints are used to enable a person to meet certain levels of calories and nutrients which are essential for healthy growth and development. Minimum levels must be met to avoid becoming malnourished, while maximum levels cannot be exceeded because over nourishment can have equally harmful effects. A person cannot consume negative amounts of food; therefore, non-negativity constraints are also necessary.[2] The objective function is:

$$(1)\ \text{Minimize } C = \sum_{i=1}^{n} x_i p_i$$

where C is the daily cost of a diet, p_i is the price of food i (i=*tortillas, rice, . . . , n foods*), and x_i is the number of servings of the *i*th food. A person must consume food in order to obtain calories for sufficient energy each day. Mathematically, this can be seen as

$$(2)\ \sum_{i=1}^{n} e_i x_i \geq E$$

[1] Stigler (1945) was the first to develop this type of model and applied it to diets developed in 1939 and 1944. Wheat flour, cabbage, spinach, navy beans, and evaporated milk were the optimal low cost foods in the diet.
[2] The Food Guide Pyramid is designed to help people understand the consumption guidelines established by the USDA. The Food Guide Pyramid is designed to represent the five food groups including, grains, vegetables, fruits, dairy and calcium-rich foods, proteins, and fats and oils.

where e_i is the number of calories in each serving of food, and E is a scalar which corresponds to the DRI for calories, based upon age and sex. E is the DRI for Calories established by the U.S. National Academy of Sciences Institute of Medicine (2006) and is equal to 1,742 calories. It is also important a person receive a certain amount of each nutrient each day to meet their DRIs for nutrients. This can be represented as

$$(3) \quad z_j = \sum_{i=1}^{n} h_{ji} x_i \qquad \forall i, j$$

where z_j is the amount of nutrient j (j= *Vitamin A*, *Vitamin D*, . . . , n) and h_{ji} is a matrix containing the amount of nutrient j in the ith food. This constraint states that the nutrients are all derived from the foods consumed daily per serving.[3] It is important that a person not receive too much of a nutrient as certain nutrients may be harmful to a person's health if consumed in excess. Excessive intake over a period of time may lead to toxicity. The amount of time required for toxicity to occur varies according to the nutrient and the individual. Thus both lower bounds (LB DRIs) and upper bounds (UL DRIs) are needed on nutrient j. This can be seen as

$$(4) \quad l_j \leq z_j \leq u_j \qquad \forall j$$

where l_j and u_j are the lower and upper bounds on nutrient j. Finally, a person cannot consume a negative amount of food. Consequently, a constraint is needed to ensure that this will happen. This equation is

$$(5) \quad x_j \geq 0 \qquad \forall j.$$

A summary of these variables is shown in Table 1. There is an established DRI for calories; however, an upper bound has not been established. Therefore, no upper bound is built in the model. The model is thus allowed to exceed the lower bound as needed.

Table 1. Definition of variables and scalars in the model

Variable or Scalar	**Definition**
x_i	Number of servings of food $_i$ where $_i$ =bread, rice, tortillas, spaghetti, cheese, sour cream, milk, yogurt, beef, chicken, pork, beans, eggs, avocados, green pepper, tomato, onion, potato, bananas, papaya, mango, plantains, coffee, Coca-Cola, Churros, multi-nutrient bar
z_j	Number of units of nutrient $_j$, where $_j$ = vitamin A, vitamin D, riboflavin, niacin, vitamin B-12, vitamin B-6, vitamin C, calcium, phosphorus, potassium, iron protein, folate, and zinc.
h_{ji}	Matrix which has the amount of nutrient $_j$ in each food $_i$.
e_i	Amount of energy (measured in calories) in each food $_i$.
p_i	Price of each $_i$ food.
L_j	Lower bound for nutrient $_j$
U_j	Upper bound for nutrient $_j$
E	1742 Calories

[3] This matrix is not reported in this paper (it is a 12 nutrient by 26 food matrix) but can be found in the appendices in Bosse (2006). The data came from the Nutrient Data Laboratory in the U.S. Department of Agriculture's National Agricultural Library at http://www.nal.usda.gov/fnic/foodcomp/search

It is important to know how this model's optimal solution changes when the assumptions are changed. Sensitivity of prices and selected constraints (i.e., calories, nutrients bounds, etc.) are tested by calculating arc elasticities, analyzing sensitivity reports, and creating solver tables. Once the model has been shown to reflect a reasonable representation of the needs of Honduran children, who are the recipients of the existing food aid programs, the model is used to analyze the effects of the four policy options.

Data

Consumption Data Collection

Interviews were done in Honduras with children, parents, and teachers from May to July of 2005. The region chosen for the interviews included the departments of Copan, Santa Barbara, Atlantida, Colon, Yoro, Olancho, Comayagua, Francisco Morazon, and Cortes (western northern and central Honduras). Data collection was conducted in 2005 with the help of the Land O' Lakes DairyLink team in Honduras who was working under a contract with USAID. The selected schools were chosen because they were recipients of the SNP. Some were also recipients of the UNWFP. They represented a broad geographic area with household incomes typical of those being targeted by the program. The geographic region included the very western part of Honduras where poverty and chronic malnutrition is wide-spread with almost 50% of the children exhibiting stunting (2006, 5 and 22).[4] They represent Gallo's "Povericum" or the 39% of the world's labor which is used in agriculture.[5] The more urban regions of San Pedro Sula and Tegucigalpa have malnutrition rates under 15% according to the World Bank (2006).

Schools were categorized into four classifications based on the Land O' Lakes SNP coordinator's recommendations. These were Highly Impoverished Rural, Highly Impoverished Urban, Impoverished Rural, and Impoverished Urban. In the extreme poor and very poor regions of Honduras, a recent assessment by the World Bank (2006, 19) reported that 23% of children ages six to eleven years do not attend school and 91% of children ages twelve to seventeen years of age do not attend school. The impoverished definition used in this research corresponds to the World Bank's poor definition. Thus, Highly Impoverished is analogous to Extreme Poor and Impoverished is analogous to Very Poor.

The total people participating in the interviews in 2005 were 241. This number included 82 parents, 17 teachers, and 142 students. The dietary recall method was used to collect consumption data. When using the dietary recall method, the respondent is asked to recall his or her food consumption during the 24 hours prior to the interview. The data collected included number of meals consumed per day, types of foods consumed, and number of servings per day. The children, parents, and teachers were interviewed separately in Spanish. All surveys were conducted verbally. Pictures and serving sizes of each food shown with a typical person's hand was used to help each respondent choose the correct serving size. The pictures were shown on laptop computers. This was done in order to ensure accuracy when reporting the number of

[4] A person is said to be stunted when they have low height-for-age. A person who is stunted was undernourished at some point during the growth years as a child. This happens because the body has to prioritize. It gives greater priority to the maintenance of vital functions rather than growth.

[5] 39% of the world´s labor force works in field of agriculture, in non OECD countries; which generate only 2.9%of the world GDP. These workers are poor by definition.

servings consumed. Students, parents, and teachers received a bag of Sun-Maid™ raisins (approximate value of $0.50 per bag) for participating in the interviews.

The Land O' Lakes program finished in 2005 and another research partner was identified in Honduras to assist in the research. Escuela Agrícola Panamericana Zamorano in Honduras was interested in the food policy and rural development aspects of the research. The Department of Socioeconomic and Environmental Development at Zamorano agreed to coordinate interviews and assist in data collection in 2006. In July of 2006, additional interviews were conducted with different Honduran parents, teachers, and children. The team visited nine schools from July 6 to July 20. They interviewed 201 people (in Spanish), including 31 parents, 44 teachers, and 126 students. The 2005 interview questions and methodology were used in 2006.

Nutrient Data Collection

Nutrients are the chemicals the body absorbs from food. Thirteen vital nutrients are included in the model: vitamin A, vitamin D, riboflavin, niacin, vitamin B-12, vitamin B-6, vitamin C, calcium, phosphorus, potassium, iron, protein, and folate. All of the recommended l_j and u_j are established by the Institute of Medicine of the U.S. National Academy of Sciences (2006). These are established for the United States and many countries use these as their standards. The precise amount of each nutrient contained in each serving of food was collected from the U.S. Department of Agriculture Agricultural Research Service's Nutrient Data Laboratory (2006). This corresponds to the nutrient matrix h_{ji} in equation (3) in the previous section. The AP to EP conversions were taken from Shugart and Molt (1989).

There is not a significant difference between the nutrient and calorie requirements for a typical girl or boy at eight years of age. Until age 14, males and females have the same nutrient requirements with the exception of calories. Models for this research were run for an eight-year-old male. This particular age and sex combination was chosen because it best suited the average Honduran child surveyed during consumption data collection.

Price Data Collection

Honduras, like many low income countries, does not publish food price data. Therefore, food price data was collected by Supermercado, Junior Barrio Barandillas in San Pedro Sula, Honduras on June 27, 2005 and again on July 9, 2006. Serving sizes were taken from University of Illinois Extension (2007) which is used by food service and homemakers for serving conversions. These data are shown in Table 3. The relative prices of food have not changed significantly over the past five years as the exchange rate of $1 to Lempira, the Honduras currency, has ranged from 17.9 to 19.1 over the 2001 to 2006 time period and the 2005 average currency equivalent of 18.88 lempiras to $1 was used. Honduras has a large amount of income remittances from immigrants working in the United States (estimated at $2 billion by the World Bank in 2004) which has helped stabilize its relative food prices and overall economy.

The price and serving size data were used to create the inputs for the mathematical optimization process. The cost function of equation (1) was minimized subject to the constraints from equations (2) to (5). The food diet generated from the optimization problem was then used to analyze the four policy options. The optimal food diet is compared against alternative food diets which may be more feasible given income limitations.

Diets Included in the Study

The median diets for each of these school types were determined from the interviews. The median diets were further classified into economical, moderate, and elaborate diets. An economical diet was considered to be the most restricted median diet found, the moderate was slightly less restricted, and the elaborate diet was the least restricted median diet as determined from the consumption data. Each school had different foods in their diets.[6]

Results

The results compare the best feasible diet against the median diets as well as the three existing programs (Land O'Lakes SNP, UNWFP, and combined program) and the policy options.

Comparison of the Diets

Tables 2, 3, and 4 provide the results based on servings, cost and nutrition (see Appendix). Table 2 shows the existing servings provided by the two food aid programs and the combined program. The cost data in the bottom row corresponds to the cost found when these serving sizes are fixed in the model and solved. They provide a baseline to better understand the cost of the policy options. Figure 2 shows how these foods meet the DRIs (see Appendix). Table 3 shows the original prices and the conversions necessary to convert food prices into prices per serving. Table 4 shows the median diets for the representative school and diet combination (impoverished rural school child's economical diet). Column 1 shows the foods which were reported being consumed daily. Column 2 shows the servings of the foods consumed daily while column three shows the servings after the inclusion of the combined program (column 2 in Table 4 plus column 4 in Table 2). The last column in Table 4 shows the best feasible diet found by optimizing the objective function subject to the constraints.

As additional constraints are imposed upon the models, the cost of the best feasible diet bundle increases ($0.33 per day for the existing diet in column 2 in table 4 to $0.92 per day for the optimal diet in column 4 in table 4). This is expected as it will be more costly to meet the additional calorie and nutrient requirements. A food not included in the diet is not necessarily less wholesome; it simply supplies those nutrients at a higher cost than another food in the mix. As nutrient-dense, low-cost foods are added to the matrix, total cost of the optimal food bundle decreases. The optimization model recognizes nutrient-dense, low-cost foods as being optimal foods for the optimal mix. It should be noted that while this is the optimal solution for this model, this particular diet was never observed in any of the interviews and represents a significant increase in daily nutrition that may not be attainable given the economic conditions of the regions where the research was conducted. In addition, some foods in this diet, such as potatoes may not be readily available.

[6] Thus, there are 12 different possible combinations of diets (four school types multiplied by three types of diets). The research in this paper reports only one which was the most common diet found in the interviews. The results for the other combinations can be found in Bosse (2006).

Table 2. Number of servings and daily cost of foods provided by Land O' Lakes School Nutrition Program, United Nations World Food Program, and the combined programs

	Land O' Lakes School Nutrition Program	United Nations World Food Program	Land O' Lakes and World Food Program Combined
Name of Food	Number of Servings of Food (x_i)		
Bread			
Rice		1	1
Tortillas	1		1
Spaghetti			
Cheese	1		1
Crema			
Milk	1		1
Yogurt			
Beef			
Chicken			
Pork			
Beans		1	1
Eggs			
Avocados			
Green Pepper			
Tomato			
Onion			
Potato			
Bananas			
Papaya			
Mango			
Plantains			
Coffee			
Coca-Cola			
Churros			
Multi-Nutrient Bar	1		1
Daily Cost per Child	$0.45	$0.06	$0.51

Table 3. Prices, quantities, serving size, and cost per serving for selected food products data

Food (i)	Brand of the sample	Price (L)	AP	CR	EP (g)	Serving Size (g)	Number of Servings	Cost Per Serving (L)	Cost per Serving $
Bread	Superman semita	14.6	480	1	480	30	16	0.91	0.05
Rice	Progresso Arroz[a]	4.25	350	3.5	1225	93	13.17	0.32	0.02
Tortillas	Tortillas Maya	4.49	550	1	550	25	22	0.2	0.01
Spaghetti	Mi Pasta/Sauce	8.9	313.4	2.5	783.5	125	6.27	1.42	0.07
Cheese	Leyde Quesillo	37	454	1	454	28.35	16.01	2.31	0.12
Sour Cream	Leyde Crema	8.75	227	1	227	4.72	48.04	0.18	0.01
Milk	Sula Leche	10.8	946.06	1	946.06	236.59	4	2.7	0.14
Yogurt	Yoplait	9.99	125	1	125	245	0.51	19.58	1.03
Beef	Carne-bistec	39.8	453.59	0.7	317.51	85	3.74	10.65	0.56
Chicken	Pollo	31.25	1133.98	0.5	566.99	85	6.67	4.68	0.25
Pork	Carne de cerdo	25	453.59	0.46	208.65	85	2.45	10.18	0.54
Beans	Frijol Cosecha	39.6	1816	2.38	4313	88.5	48.73	0.81	0.04
Eggs	Mama Gallina Huevos	22.99	930	1	930	62	15	1.53	0.08
Avocado	Fresh	4.99	202	0.67	135.34	75	1.8	2.77	0.15
Sweet Peppers	Fresh	8.6	145.12	0.73	105.94	70	1.51	5.68	0.3
Tomatoes	Fresh	5.93	299.37	0.9	269.43	90	2.99	1.98	0.1
Onion	Fresh	5.72	589.67	0.78	459.94	80	5.75	0.99	0.05
Potatoes	Fresh	5.72	589.67	0.74	436.36	78	5.59	1.02	0.05
Bananas	Fresh	1.65	250.77	0.65	163	59	2.76	0.6	0.03
Papaya	Fresh	23.14	870	0.62	539.4	70	7.71	3	0.16
Mango	Fresh	4.5	420	0.69	289.8	82.5	3.51	1.28	0.07
Plantains	Fresh	2.99	330	0.66	217.8	77	2.83	1.06	0.06
Coffee	Oro Café	26.6	453.59	38.61	17512.61	177.75	98.52	0.27	0.01
Coca-Cola	Coca-Cola	17.5	2076.18	1	2076.18	184	11.28	1.55	0.08
Churros	Churros	1	28.35	1	28.35	28.35	1	1	0.05
Multi-Nutrient Bar	Proassa	3.39	1	1	20	1	1	3.39	0.18

[a] Rice is an example used to explain this table. Rice is the food in column one. Progresso Arroz is the brand of rice purchased at the supermercado. The entire package cost 4.25 Lempiras (L) and had a total weight (AP) of 350 grams. Foods weigh different amounts when they are purchased (as purchased AP) and when they are ready to consume (edible portion EP). Therefore, an established conversion must be used to calculate the EP. The conversion ratio (CR) was 3.5 which leads to the edible portion (EP) weighing 1225 grams (3.5*350 g or grams). A serving of rice (1/2 cup) weighs 93 grams. The number of servings in the container are 13.17 (1225 grams divided by 93 grams), which makes the cost per serving 0.32 L or approximately 0.02 US dollars.

Table 4. Comparison of the Food $_i$ and cost for the food programs and the Optimal Diet of foods for the Impoverished Rural School Economical Median Diet

Food *i*	Dietary Food Recall Surveys[a]	Dietary Food Recall Surveys & Land O' Lakes & World Food Program School Nutrition Programs[b]	Optimal Diet[c]
Bread			
Rice	2	3	4.05
Tortillas		1	2.83
Spaghetti			1.16
Cheese	1	2	
Crema			
Milk		1	2.04
Yogurt			
Beef			
Chicken			
Pork			
Beans	4	5	1.31
Eggs			0.69
Avocados			
Green Pepper			
Tomato			
Onion			
Potato			3
Bananas			
Papaya			
Mango			
Plantains			2.93
Coffee			
Coca-Cola			
Churros			
Multi-Nutrient Bar			0.04
Cost	$0.33	$0.66	$0.92

[a]This diet is the number of servings found in the impoverished rural economical median diet determined from the surveys.
[b]This diet was received by the students who attended a school which received the Land O'Lakes and UNWFP SNPs in addition to their regular diet.
[c]This diet is the number of servings found in the optimal low-cost diet.

Table 5 displays the percentage of DRIs met by the impoverished rural economical diet, the food programs, and the best feasible diet. Analysis of the data shows that the students are better nourished with the programs than they are without the programs. This is determined by the amount of each of the DRIs met by the diets evaluated. The best feasible diet mix would be ideal as it meets all DRIs without providing harmful excess of the nutrients.

Table 5. Comparison of the DRIs received from the Impoverished Rural Economical Median Diet, the food programs, and the Optimal Diet

Nutrient	Dietary Food Recall Surveys[a]	Dietary Food Recall Surveys & Land O'Lakes & World Food Program School Nutrition Programs[b]	Optimal Diet[c]
Energy	0.45	0.76	1.00
Vitamin A, RAE	0.04	0.24	1.00
Vitamin D	0.00	0.47	1.02
Riboflavin	0.50	1.46	2.56
Niacin	0.36	0.55	1.88
Vitamin B-12	0.24	1.34	2.12
Vitamin B-6	0.18	0.52	2.89
Vitamin C	0.17	0.21	1.74
Calcium	0.37	1.02	1.00
Phosphorus	1.39	2.55	2.45
Potassium	0.40	0.60	1.00
Iron	1.09	1.43	1.00
Protein	2.19	3.52	2.70
Folate	2.33	3.13	2.00
Zinc	1.09	1.76	1.53
UL Vitamin A, RAE	0.02	0.11	0.44
UL Vitamin D	0.00	0.05	0.10
UL Niacin	0.19	0.29	1.00
UL Vitamin B-6	0.00	0.01	0.04
UL Vitamin C	0.01	0.01	0.07
UL Calcium	0.12	0.33	0.32
UL Phosphorus	0.23	0.43	0.41
UL Iron	0.27	0.36	0.25
UL Folate	1.17	1.56	1.00
UL Zinc	0.45	0.73	0.64

[a]This diet is the number of servings found in the impoverished rural economical median diet determined from the surveys. For example, the DRI for Energy is 0.45 or 45% of the recommended DRI which is 100%.
[b]This diet was received by the students who attended a school which received the Land O'Lakes and UNWFP SNPs in addition to their regular diet.
[c]This diet is the number of servings found in the optimal low-cost diet.

Sensitivity of the Model to Key Variables

Previous literature states different numbers for the recommended intake for calories. For example the American Heart Association (2006) recommends 1400 calories for a male four to eight years of age and Foster and Leathers (1992) recommends 2,400 calories for a seven to 10-year-old child. We imposed this figure on our results. Due to the discrepancies in the literature regarding the number of calories required for growth and development and the fact that the average Honduran child is much more active than an average child in the United States because of their work in agriculture, household duties, and active leisure time, a solver table was generated to look at the impact of increasing this calorie constraint by 10, 20, 30, 40, and 50 percent. The results are reported in Table 6. The results of the solver table show that bread, cheese, sour cream, yogurt, beef, chicken, pork, eggs, avocados, green pepper, tomatoes, onions, potatoes, bananas, papaya, mango, coffee, Coca-Cola®, and Churros® will not enter the optimal mix.[7] The number of servings of rice, tortillas, and plantains increase as the calories required increase. The number of servings of spaghetti, milk, and beans decrease as the calories required increase. As expected, the cost of the bundle increases as the required calories increase. However, the percentage increase in the cost of the mix is less relative to the percentage increase in calories.

Table 6. Impact on the Optimal Diet when increasing the number of calories required

Percentage increased	Calories[a]	Rice[b]	Tortillas[b]	Spaghetti[b]	Milk[b]	Beans[b]	Plantains[b]	Multi-Nutrient Bar[b]	Cost of Diet[c]
10%	1916	6.38	2.49	1.4	2.19	1.35	4.61	0.05	0.88
20%	2090	7.78	2.84	1.26	2.15	1.23	4.82	0.05	0.89
30%	2264	9.18	3.18	1.11	2.1	1.1	5.03	0.05	0.91
40%	2438	10.59	3.53	0.97	2.06	0.98	5.24	0.05	0.93
50%	2613	12	3.82	0.8	2.03	0.87	5.46	0.05	0.95

[a]Measured in calories.
[b]Measured as quantities.
[c]Measured in dollars.

Arc elasticities were calculated for a 1% change above and below the base cost. The elasticities of cost with respect to the price of all the foods are relatively small.[8] The elasticities indicate that a 1% change in food prices results in a less than 1% increase in costs. These results suggest that small changes in the prices of various foods cause smaller changes in the cost of the diet. Thus, even though prices may differ the model's solutions are not likely to change significantly.

Analysis of the Policy Options

In order to be feasible, food aid policies should adhere to the following criteria. They should follow nutritional guidelines, be compatible with cultural consumption habits, have sufficient shelf lives, and consider ease of distribution and preparation. The best feasible diet not only meets the DRIs without reaching levels of toxicity, it also provides the child with a variety of grains, vegetables, fruits, milk products, meat and meat alternates. Additionally, it limits the amount of fats, oils, and sweets. To determine which foods are reasonable recommendations for policy options based upon nutrition, (e.g., provision within school nutrition programs) the foods which are selected by the model for the optimal bundles are reviewed. Rice, tortillas, spaghetti, milk, beans, eggs, potatoes, plantains, and the multi-nutrient bar were selected by the model for at least one of the optimal diets. This indicates that these are low-cost, nutrient-dense food and are reasonable foods to consider in policy implementation. The foods contained in the median diets are very similar to the foods included in the diet generated by the optimization model. A

[7] These arc elasticities can be found in Bosse (2006).
[8] This is a brand of chips similar to Cheetos. They are frequently sold to students during their lunch period.

reasonable conclusion is that the foods in the optimal diet would, therefore, coincide with cultural consumption habits.

To further evaluate the reasonableness of policy recommendations, the foods are also analyzed for shelf life longevity. Shelf lives were taken from Roberts and Graham (2006). When considering policy options in Honduras, lack of refrigeration is an issue. The 2006 survey data shows that 69% of the parents did not have a refrigerator. Any food that is not shelf stable would not be a reasonable recommendation. The reported shelf lives indicate that spaghetti, multi-nutrient bars, rice, milk, beans, Churros®, and coffee are reasonable components in a school nutrition program. Since neither Churros® nor coffee ever entered an optimal solution, they were eliminated from possible policy recommendations. The resulting foods are nutritious, coincide with the culture consumption habits, and have extended shelf lives. Thus, spaghetti, multi-nutrient bar, rice, milk, and beans are considered potential foods for food aid policy.

Infrastructure within Honduras is lacking. Therefore, transportation of food to the schools could be challenging. This would especially be true in rural areas. Electricity is not readily available which hinders refrigerated storage. Milk and the multi-nutrient bar were the only two foods of the reasonable food recommendations that do not require energy for cooking or refrigeration. This feature would greatly increase the ease of distribution to the students within the schools. Both milk and the multi-nutrient bar can be produced in a variety of flavors. They can also be produced within Honduras in order to utilize local commodities, fruit, and labor.

Due to the nutrient-dense, low-cost characteristics, the ease of distribution, and the lengthy shelf lives, both milk and a multi-nutrient bar are considered reasonable food policy options.[9] Solver tables were used to analyze how price changes for milk and the multi-nutrient bar impact the best feasible diet mix selected by the model. Bread, sour cream, yogurt, beef, chicken, pork, avocados, tomatoes, papaya, mango, Coca-Cola®, and Churros® never enter the optimal solution regardless of price changes in milk or the multi-nutrient bar. This shows that these are not low-cost, nutrient-dense foods.

When a solver table was run for the price of milk, if milk could be obtained for free, the model would select 6.27 servings of milk per day in the best feasible diet mix. As the price of milk increases, the number of servings in the optimal mix steadily decreases. A partial serving of milk stays in the mix regardless of price even if one serving costs $100. This shows that milk is vital for achieving the appropriate amounts of nutrients, given these choices of foods. Since the model always factors in milk, the cost of the mix increases as the cost of a serving of milk increases. Bread, cheese, sour cream, yogurt, beef, chicken, pork, avocados, green pepper, tomatoes, onions, potatoes, bananas, papaya, mango, coffee, Coca-Cola®, and Churros® never entered the optimal mix.

If the price of the multi-nutrient bar increases to $0.28 cents per serving, the model removes the bar from the optimal mix. Regardless of how inexpensive the bar becomes, the model never selects more than 0.05 servings of the bar. This is due to the fact that the consumption of this particular bar would violate an UL DRI. This could lead to toxicity over a period of time. Thus the model was not allowed to exceed these upper bounds.

[9] The multi-nutrient bar analyzed is a product of a company in Guatemala. Similar multi-nutrient bar are distributed by various aid programs around the world.

Table 7. Respective mix and cost for Four Policy Options

	Policy Option			
	#1 Milk	*#2 Multi-Nutrient Bar*	*#3 Milk and Multi-Nutrient Bar*	*#4 Optimal Food Mix*
Food (i)				*Number of Servings of Food (x_i)*
Bread				
Rice				4.05
Tortillas				2.83
Spaghetti				1.16
Cheese				
Crema				
Milk	1		1	2.04
Yogurt				
Beef				
Chicken				
Pork				
Beans				1.31
Eggs				0.69
Avocados				
Green Pepper				
Tomato				
Onion				
Potato				3
Bananas				
Papaya				
Mango				
Plantains				2.93
Coffee				
Coca-Cola				
Churros				
Multi-Nutrient Bar		1	1	0.04
Daily Cost per Child	$0.14	$0.18	$0.32	$0.92
Annual Cost per Child	$52.05	$65.42	$117.47	$336.43

Cost of the Policy Options

By fixing the servings of the policy options in the model, the costs (Table 7) and DRIs (Figure 3) can be calculated. The policies vary in effectiveness and cost. Nutrition programs can be either supplemental, meaning they fulfill part of the DRIs for nutrients or calories or they can be nutritionally complete, meeting 100% of the DRIs for nutrients and calories. Policy options 1 through 3 are supplemental nutrition programs while policy 4 is a nutritionally complete nutrition program.

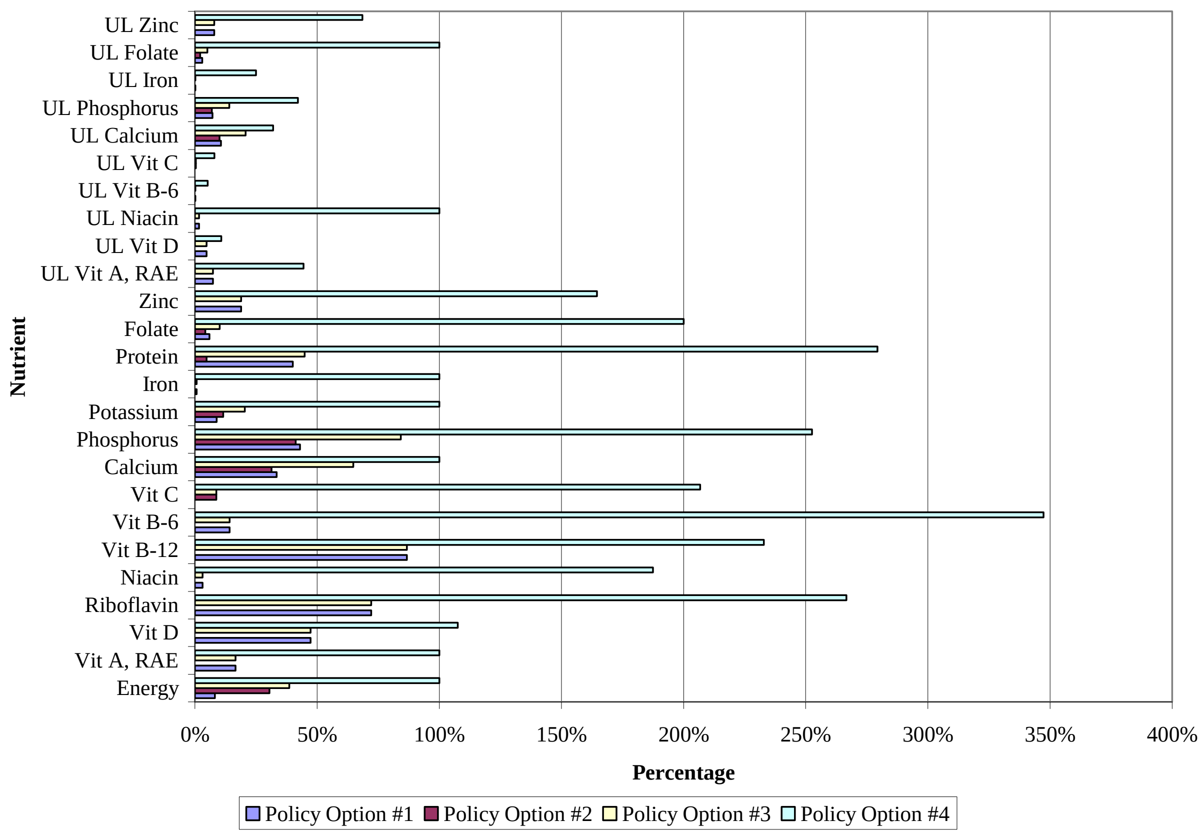

Figure 3. Percentage of dietary reference intakes received from the Four Policy Options

The first policy option analyzed is the provision of milk. Milk appeared in the majority of the optimal diets. It is both nutrient-dense and easily distributed with the ultra-high temperature technology. The second policy option tested in this model is the provision of a multi-nutrient bar. The specific multi-nutrient bar evaluated in this paper would not be ideal in its current form due to issues with toxicity. None of the other bars evaluated exceed the toxicity levels; therefore, it is assumed that modification is possible. If modified, the multi-nutrient bar could be ideal as it could be a low-cost solution to nutrient and calorie deficiencies in addition to eliminating parasites. During consumption data collection, it became clear that elimination of parasites was key to the success of any SNP.[10]

The third policy option is the provision of both milk and the multi-nutrient bar. These are an excellent combination both in terms of nutrition and convenience. The fourth policy option is the provision of the optimal food bundle. This would provide the children with a nutritionally complete diet. This could be divided into two or three meals during the school day or taken home.

[10] According to numerous statements in the World Food Programme publication (2006), parasites are a common health issue in low income countries. Parasites affect the absorption of nutrients and negatively impact the overall health of the individual. Land O' Lakes ran tests prior to the implementation of their program and found that 95 percent of the children tested had parasites. Due to the antiparasitic nature of the multi-nutrient bar, it is assumed that parasites were eliminated after the implementation of the program; however, results from post-implementation tests were not reported.

Discussion of Overall Economic Analysis

As discussed previously, malnutrition while prevalent throughout Honduras, is more widespread in rural regions than in urban areas. Because the program described here is carried out in schools, its impact would be greatest in rural regions especially in the departments located in western Honduras (e.g., Copan, Ocotepeque, Lempira, and Santa Barbara). In particular, its impact would be greatest for children in the six to 11 years of age category who are enrolled in school and lowest for children under the age of six who are not enrolled in school. Kain, Uauy, and Taibo (2002) note that, as a nutrition program becomes more important to the overall household food budget, parents are more inclined to ensure that their children are enrolled in school. Kennedy (1999) suggests that the net benefits of a school nutrition program increase if the benefits are found to be a larger share of the household budget.

A targeting approach could be used for this school nutrition program similar to what is done in Chile’s School Feeding Program (2002). A committee at each school determines which children receive different types of foods based on calories. Children in rural areas where malnutrition was greatest, such as the rural departments in western Honduras, could receive quantities of foods in the third or fourth policy option whereas children in urban areas where malnutrition was less severe could receive different quantities of foods. Such a targeting approach could maximize the overall economic impact of the school nutrition program.

Furthermore, including nutrition education for parents of the children receiving the school nutrition program could help increase the impact of the program. Beretta et al. (1998) found a positive impact on the overall household nutrition from such programs. Such an education program was observed in some but not all of the schools where the interviews were conducted for this research. Duran, Caballero, and Onis (2006) found a positive correlation between stunting and underweight preschool children in Central America but also noted that obesity was increasing in this region.

The World Bank’s Poverty Assessment Report (2006, p.59) found that Honduras’ public food programs and rural development programs were appropriately targeted at high-poverty and considered pro-poor (e.g., the poor receive more of the program benefits than non-poor students) programs. This would suggest that a school nutrition program such as the one described in this research could be administered by the government which might help lower costs in the long-run.

Conclusions

The use of nutrition being used in food aid programs is becoming an important topic for agribusiness and food business firms especially in countries such as Honduras. Former President Bush proposed to allow food aid recipients to purchase up to 25% of their food from domestic food suppliers rather than US agribusiness companies in an effort to improve nutrition. This was controversial. President Obama has not taken up this issue yet but there is a bill in the US Congress to consider a similar program. It is apparent that agribusiness firms involved in food aid will need to recognize the role of nutrition in food aid programs in the future.

Cost increases when moving from supplemental nutrition programs to nutritionally complete programs. Improvement in nutrition is correlated with the price of the program. The choice of the most suitable option is dependent upon the condition of the children in the school and the available financial support. There is a strong relationship between malnutrition, and education, productivity and poverty. The UNWFP has begun micronutrient fortification in its programs (2006). Other organizations engaged in nutrition programs can learn from the UNWFP in southern Africa and the Indian subcontinent where it worked with local processors in microfortification. A nutrition education program is vital in accompanying SNP to help provide education on the nutrition paradox. Microfortification can help improve the nutritional content of SNPs. Food aid should reflect nutrition if the policy goal is to reduce malnutrition and improve productivity, all of which will help reduce poverty.

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