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USDA's Low-Cost, Moderate-Cost, and Liberal Food Plans: Development and
Expenditure Shares

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I. Introduction

The USDA Low-Cost, Moderate-Cost, and Liberal Food Plans demonstrate that one can eat a healthful, nutritionally adequate diet at three expenditure levels (Carlson, et al., 2007). The Low-Cost Food Plan costs less than what the average American currently spends on food and meets the 2005 Dietary Guidelines for Americans and MyPyramid. Alternatively, one could purchase more expensive foods by following the Moderate-Cost or Liberal Food Plan. These plans also meet the 2005 Dietary Guidelines and MyPyramid. All three food plans have been revised recently by using a mathematical optimization model. This paper will detail the model and discuss relative expenditures of various food groups for each of the three plans as well as the estimated average expenditures of consumers.

The three food plans are used for various purposes: bankruptcy courts often use the value of the Low-Cost Food Plan to determine the portion of a bankrupt person's income to allocate to necessary food expenses. The Department of Defense uses the value of the Liberal Food Plan to determine the Basic Allowance for Subsistence rate for all servicemembers. All three food plans are used by divorce courts in setting payment for alimony, and in the USDA report *Expenditures on Children by Families* (Lino, 2007), which is used to set State child support guidelines and foster care payments.

The market baskets of the Low-Cost, Moderate-Cost, and Liberal Food Plans specify the types and quantities of foods that people could purchase and prepare at home to obtain a nutritious diet at three cost levels. For each food plan, there are 15 market baskets—one

for each of 15 age-gender groups. The Low-Cost Food Plan represents food expenditures in the second from the bottom quartile of estimated food spending; the Moderate-Cost Food Plan, food expenditures in the second from the top quartile of food spending; and the Liberal Food Plan, food expenditures in the top quartile of food spending.

II. Food Plan Development

Data. There were two main data sets used in the most recent update of the USDA Food Plans: the Federal Government's 2001-02 National Health and Nutrition Examination Survey (NHANES) and the 2001-02 CNPP Food Prices Database. NHANES contains the results of a 24-hour dietary recall interview as well as the nutrient content of the foods reported consumed. More information on the NHANES data can be found elsewhere (Centers for Disease Control and Prevention and U. S. Department of Agriculture, 2004). Pregnant and lactating women were excluded as well as those with incomplete dietary recall records. The final sample size used from NHANES was 6,753 individuals who reported consuming, in total, 4,152 foods. The CNPP Food Prices Database is an estimated national average price for all foods reported consumed in NHANES. This database was created by merging information about food consumption from NHANES with national data on food prices from the 2001-02 Nielsen Homescan panels. To create this database, USDA's Center for Nutrition Policy and Promotion (CNPP) staff broke the foods down into purchasable ingredients and estimated the quantity to purchase, given the refuse loss from peels, skins, bones, seeds and other non-edible parts as well as the amount of moisture lost and gained in the cooking process. All foods are assumed to be prepared at home with convenience items factor in, including frozen entrees, frozen and

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canned fruits and vegetables, prepared soups and sauces, shelled nuts and shellfish, fillet fish and canned and frozen dried beans. More information on the CNPP Food Prices Database can be found elsewhere (Carlson, et al., 2008).

Model. The USDA Food Plans were estimated by using a Mathematical Optimization model. Figure 1 provides an overview of the model, and Figure 2 shows the mathematical statement of the model. Each age-gender group was estimated separately by using the GAMS-IDE minos and conopt solvers. For each age-gender group, the model selected the optimal quantity of food that meets the overall cost constraint as well as the dietary standards. The cost constraint was based on the average cost of a particular plan for an age-gender group in 2001 and 2002. Dietary standards were set by the 2005 Dietary Guidelines for Americans (*U. S. Department of Health and Human Services and U. S. Department of Agriculture, 2005*) and include the Daily Reference Intakes (DRIs) and the quantities of foods specified in MyPyramid (MyPyramid.gov).

The foods reported consumed were divided into 58 categories such as whole-grain breakfast cereals; dark-green vegetables without added fat; dark-green vegetables with added fat; citrus fruit, melons and berries; juice made from citrus fruits, melons and berries; poultry with low solid fat; and sugars and sweets. The nutrient content, number of pyramid cup and ounce equivalents¹, and the cost per gram for each food category were estimated based on the consumption of foods within the category. For example, the whole-grain cereal category includes oatmeal and ready-to-eat cold whole-grain cereals.

¹ Because of consumer confusion over the amount of food in a “serving”, USDA changed the quantities of food in MyPyramid from “servings” to cup-equivalents of milk, fruit, and vegetables, and ounce-equivalents of lean meat, and 1 slice of bread.

NHANES data provide an estimate of the total number of grams that are consumed for each age-gender group as well as the amount of each nutrient consumed. The amount of each nutrient per gram in the whole-grain cereal category is a weighted average of the amount per gram of the nutrient in each cereal, where the weights are the amount of each food consumed by the age-gender group.

Market Baskets. The model output gives the optimal quantity of each of the 58 food categories for each age-gender group. Since these categories are of food that is ready to eat, rather than foods in the form found in the grocery store, the foods were reformatted into purchasable ingredients. These ingredients were then grouped into 29 market basket groups, based on how foods might be grouped in a store. Finally, the quantities were converted to pounds for consumer education purposes. These lists of 29 market basket groups and the associated quantities are the official USDA Food Plans and are used to update the cost of the plan each month. Each market basket group is linked to one or more CPIs for various food items, and the cost of these groups is updated each month to determine an overall monthly market basket cost.

This paper also focuses on differences in the allocation of the food budget between the average consumer and the food plans, using expenditure shares. The expenditure shares for each group are calculated by taking the ratio of the cost of each market basket group to the total cost of the food. In order to focus the discussion, we present the shares for the Low-Cost, Moderate-Cost and Liberal Plans as a weighted average of all 15 age-gender

groups, where the percentage of the population in each age-gender group according to the U.S. Census provides the weights

III. Results

The complete results for the USDA Food Plans are given elsewhere (*Carlson, et al., 2007*), and only the expenditure shares of the plans are presented in Table 1 for each of the 29 market basket groups along with the expenditure shares based on the weighted average consumption by consumers with food spending corresponding to each plan. The Low-Cost consumers are those with food spending in the second from the bottom quartile, the Moderate-Cost consumers are in the second from the top quartile, while the Liberal consumers are in the top quartile. Also shown in Table 1 are the estimated total expenditures per day for each spending quartile and the cost of the food plan. For comparison, the weighted average cost of the Thrifty Food Plan market basket in 2002 dollars is \$3.82. The Thrifty Food Plan cost is considered by USDA to be the minimal cost of a healthful diet (*Carlson, et al., 2007*).

The first point to be made is that most consumers could eat a much more healthful diet for what they are currently spending on food. In fact, many consumers could spend less. Among the consumers included in the second quartile of expenditures (Moderate Cost) are consumers who income-qualify for food stamps. They, and other consumers who would like to spend the minimal amount on food, may wish to consider following the Thrifty Food Plan, rather than the Moderate-Cost Plan. The required shifts in the food

budget when moving from average consumption in each spending quartile to the corresponding food plan are about the same. The average consumer needs to shift expenditures on meat and meat alternatives, and other foods to fruits and vegetables. Expenditures on dairy, especially skim and 1% milk, should increase slightly.

Table 1 also demonstrates changes within the food group for consumers who wish to eat a healthful diet. For comparison, Table 2 shows how the budgets for each food category are different between the food plans and average expenditures. A larger fraction of the grain budget should go towards whole-grain breads, cereal, popcorn and other whole-grain snacks, and less on non-whole grain foods. This is also reflected in the total budget shares in Table 1. Expenditures on all vegetable sub-groups are higher in the food plans than in the average consumption baskets (Table 1), but relatively more of the increase in expenditures on vegetables goes towards dark greens, deep yellow, legumes and a slight increase in potatoes. Note that the GAMS food categories distinguish between high fat-added potato and lower fat potato dishes, and the solution for most age-gender groups favors the lower fat potato dishes over the high fat-added potatoes such as French fries and hash browns. Within fruits, the food plans' expenditure shares contain more whole fruit and less juice than what the average consumer currently reports eating or drinking. Finally, the milk group has only a slight overall increase in the expenditure share, but the expenditure share suggests a large shift from high fat milks, cheese, and milk desserts towards low-fat and skim milk.

For the meat and meat alternatives food group, the expenditure shares for the average consumer are generally higher for red meat, poultry, and eggs than are the expenditure shares of the food plans. The Low-Cost and Liberal Plans also have a lower expenditure share for fish, but the Moderate-Cost Plan allocates more of the budget to fish than the average consumer does. In all three plans, there is an increase in the expenditure shares on nuts and nut butters. All sub-categories within Other Foods have a smaller share of the total budget in the food plans than what the average consumer currently spends. However, within Other Foods, the shares in the food plans favor soups, table fats and salad dressings, and gravies, sauces and condiments. This last result is not surprising since these are the ingredients that enhance the taste of vegetables.

The USDA Food Plans demonstrate how consumers can obtain a healthy diet at any expenditure level. This paper's main goal was to compare the suggested expenditure shares of the food plans with the shares based on food spending of the average consumer. This comparison finds that consumers can obtain a more healthful diet based on what they are currently spending on food; to do so, they need to spend more on vegetables (including legumes), fruits, and milk products, and less on meat and meat alternatives and other foods. These results are similar to the changes recommended in intakes for diets to be healthful as reported in the 2005 Dietary Guidelines (*U. S. Department of Health and Human Services and U. S. Department of Agriculture, 2005*). Differences may have resulted from the fact that our analysis is a weighted average of all consumers, while the Dietary Guidelines reports only changes needed for males and females between the ages of 31 and 50.

Figure 1: Schematic of food plans

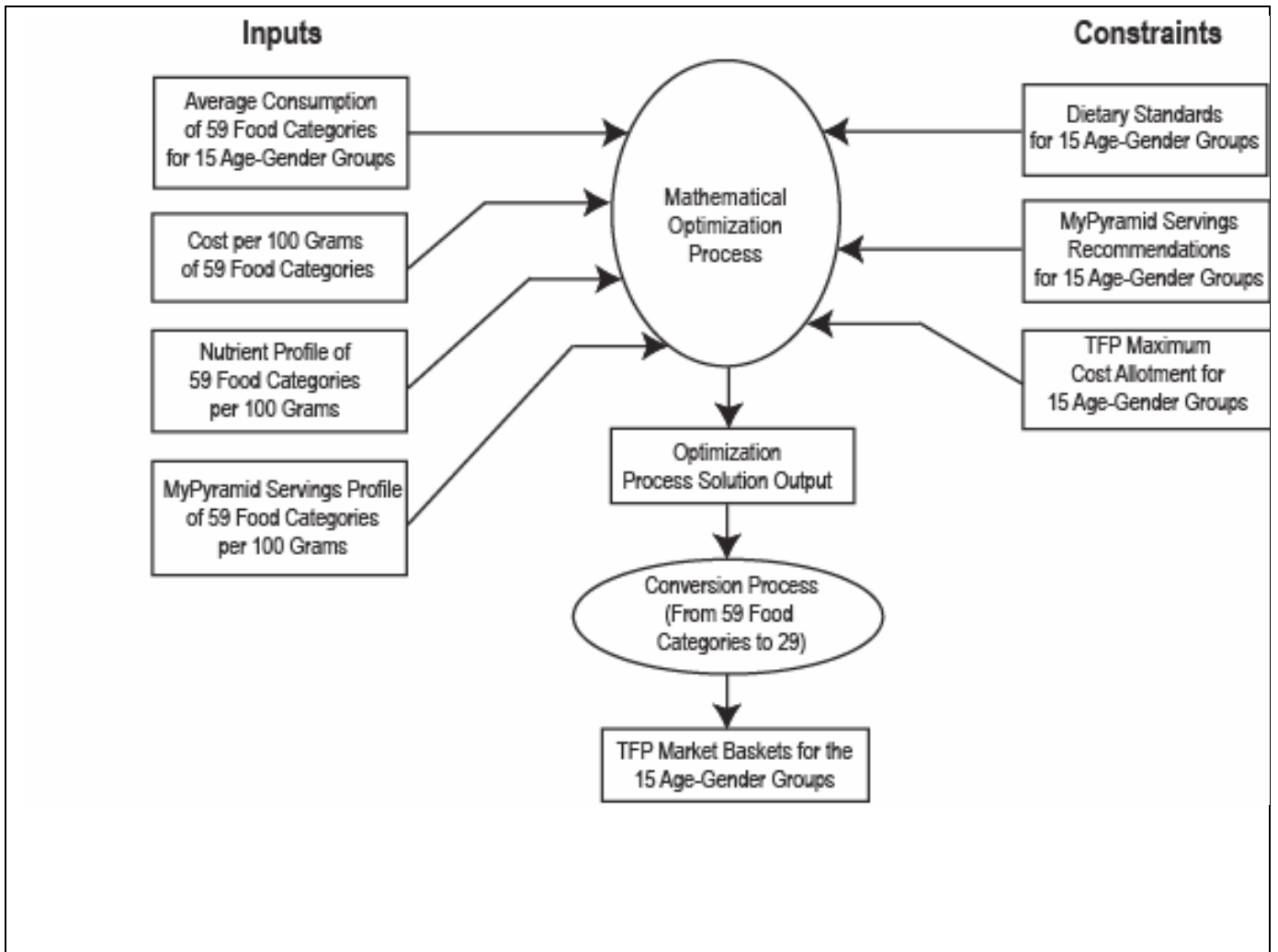


Figure 2: Mathematical statement of model

Optimization Model of the Low-Cost, Moderate-Cost, and Liberal Food Plans

Minimize the objective function:*

$$\sum_f (\text{FBS})_f (\ln (\text{FP})_f - \ln (\text{Current})_f)^2$$

Subject to:

$$\sum_f (\text{FP})_f (p)_f \leq \text{Set Cost Limit}$$

$$\sum_f (\text{Quantity of nutrient group in } \text{FP})_f \geq 1997\text{-}2005 \text{ RDA/AI/AMDR}$$

$$\sum_f (\text{Quantity of nutrient group in } \text{FP})_f \leq \text{upper limit if applicable}$$

$$\sum_f (\text{Amount of total fat in } \text{FP})_f > \text{lower limit set by AMDR for age group}$$

$$\sum_f (\text{Amount of total fat in } \text{FP})_f \leq \text{upper limit set by AMDR for age group}$$

$$\sum_f (\text{Amount of saturated fat in } \text{FP})_f < 10\% \text{ of total kilocalories}$$

$$\sum_f (\text{Amount of linoleic acid in } \text{FP})_f \geq 5\% \text{ of total calories}$$

$$\sum_f (\text{Amount of linoleic acid in } \text{FP})_f \leq 10\% \text{ of total calories}$$

$$\sum_f (\text{Amount of } \omega\text{-linolenic acid in } \text{FP})_f \geq 0.6\% \text{ of total calories}$$

$$\sum_f (\text{Amount of } \omega\text{-linolenic acid in } \text{FP})_f \leq 1.2\% \text{ of total calories}$$

$$\sum_f (\text{Amount of carbohydrates in } \text{FP})_f \geq 45\% \text{ of total calories}$$

$$\sum_f (\text{Amount of carbohydrates in } \text{FP})_f \leq 65\% \text{ of total calories}$$

$$\sum_f (\text{mg of cholesterol in } \text{FP})_f \leq 300 \text{ mg}$$

$$\sum_f (\text{grams of fiber in } \text{FP})_f \geq 14 \text{ g/1,000 calories}$$

$$\sum_f (\text{mg of sodium in } \text{FP})_f \leq \text{median consumption of sodium for age-gender group or upper limit, whichever is higher}$$

$$\sum_f (\text{Calories in } \text{FP})_f = \text{IOM equation for median height and weight at low activity level } \pm 5 \text{ percent}$$

$$\sum_f (\text{Number of MyPyramid group servings in } \text{FP})_f \geq \text{Recommended for calorie pattern}$$

$$(\text{FP})_f > 0$$

$$(\text{FP})_f \leq (\text{Upper Limit}) (\text{Current})_f$$

Where:

$$\text{FBS}_f = \text{Food Budget Share} = \frac{p_f (\text{Current})_f}{\sum_f p_f (\text{Current})_f}$$

f = food group (58 food groups)

p_f = price of food group f

FP_f = amount of food for 1 day in food group f at Food Plan level in grams

Current_f = amount of food for 1 day in food group f at Current Consumption level in grams

Nutrient group = protein, thiamin, riboflavin, niacin, folate, calcium, copper, phosphorus, potassium, magnesium, iron, zinc, vitamins A, E, C, B₆, B₁₂

Upper Limit = multiplier set on a case-by-case basis to allow the model to meet both the MyPyramid requirements and prevent an unreasonable amount of any one food group

RDA = Recommended Dietary Allowances

AI = Adequate Intakes

AMDR = Acceptable Macronutrient Distribution Ranges

*The objective function states that the food plan basket should be as close to current consumption as possible. The food budget share (FBS) weight gives higher priority to food groups on which consumers spend more of their budgets. The food plan objective function is constructed to minimize the distance between optimal food consumption and current consumption while simultaneously meeting the 14 group constraints listed under "Subject to."

Table 1: Expenditure Shares

	USDA Food Plans			Average Consumption		
	Low Cost	Moderate Cost	Liberal	Low Cost Consumer	Moderate Cost Consumer	Liberal Consumer
Grains						
whole grain breads, rice, and pasta	6.13%	6.16%	4.47%	0.54%	0.64%	0.54%
whole grain cereal	3.08%	2.97%	4.17%	1.78%	2.04%	1.78%
popcorn and other whole grain snacks	1.32%	3.43%	2.16%	0.50%	0.78%	0.50%
non-whole grain breads, cereal, rice, pasta, and snacks (including frozen breads)	4.87%	5.51%	5.25%	9.02%	11.05%	9.02%
Total	15.41%	18.06%	16.04%	11.83%	14.51%	11.83%
Vegetables						
all potato products	2.62%	2.08%	2.04%	1.29%	1.62%	1.29%
dark green vegetables	4.21%	5.62%	5.83%	1.27%	0.91%	1.27%
other vegetables	8.96%	9.27%	8.78%	8.45%	8.11%	8.45%
deep yellow vegetables	2.23%	2.56%	2.07%	0.59%	0.55%	0.59%
dry and canned beans, lentils, peas (legumes)	4.94%	6.91%	7.45%	4.63%	3.59%	4.63%
Total	22.97%	26.44%	26.17%	16.22%	14.79%	16.22%
Fruits						
whole fruits	15.32%	12.68%	16.01%	6.31%	6.36%	6.31%
fruit juices	2.82%	2.56%	1.78%	2.98%	3.45%	2.98%
Total	18.14%	15.24%	17.80%	9.29%	9.81%	9.29%
Milk						
whole milk, yogurt, cream	1.18%	0.46%	0.44%	9.29%	9.81%	9.29%
low fat and skim milk, lowfat yogurt	11.32%	12.21%	11.38%	2.00%	2.24%	2.00%
all cheese (including cheese soup & sauce)	1.36%	0.54%	0.66%	3.48%	4.09%	3.48%
milk drinks and milk desserts (including dry mix and soy based drinks)	0.72%	0.27%	0.68%	4.35%	4.69%	4.35%

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Total	14.58%	13.49%	13.17%	19.13%	20.83%	19.13%
Meat and Meat Alternatives						
beef, pork, veal, lamb, game	7.30%	5.70%	6.20%	13.50%	12.27%	13.50%
chicken, turkey, game birds	3.87%	7.19%	3.15%	5.13%	6.85%	5.13%
fish and fish products	4.51%	6.19%	8.88%	8.37%	3.20%	8.37%
bacon, sausages, luncheon meats (including spreads)	0.83%	0.42%	0.68%	2.88%	3.29%	2.88%
nuts and nut butters & seeds	5.03%	3.04%	3.24%	0.87%	0.83%	0.87%
eggs and egg mixtures	0.34%	0.19%	0.17%	0.82%	1.08%	0.82%
Total	21.88%	22.72%	22.31%	31.57%	27.52%	31.57%
Other Foods						
table fats, oils and salad dressings	1.06%	0.81%	0.91%	1.36%	1.52%	1.36%
gravies, sauces, condiments, spice, salt	0.87%	0.69%	0.89%	1.33%	1.53%	1.33%
coffee, tea	0.14%	0.06%	0.04%	0.24%	0.38%	0.24%
soft drinks, sodas, fruit drinks (including rice beverage)	2.97%	0.94%	1.21%	8.72%	9.57%	8.72%
sugars, sweets, candies	0.87%	0.29%	0.45%	3.75%	3.74%	3.75%
soups - RTS and condensed	0.69%	0.83%	0.69%	0.94%	1.15%	0.94%
soups - dry	0.14%	0.07%	0.11%	0.13%	0.14%	0.13%
frozen or refrigerated entrees (including pizza, fish sticks, frozen meals)	0.18%	0.26%	0.10%	0.70%	0.82%	0.70%
Total	6.92%	3.96%	4.41%	17.16%	18.84%	17.16%
Total Daily Expenditure (2002 prices)	\$4.88	\$6.03	\$7.33	\$4.33	\$6.37	\$8.97

Table 2: Comparative Expenditure Shares of Market Basket Groups

Note: Each group sums to 100%

	Low Cost	Moderate Cost	Liberal	Low Cost Consumer	Moderate Cost Consumer	Liberal Consumer
Grains						
whole grain breads, rice, and pasta	39.78%	34.08%	27.88%	4.54%	4.39%	4.54%
whole grain cereal	20.01%	16.44%	25.96%	15.04%	14.07%	15.04%
popcorn and other whole grain snacks	8.57%	18.98%	13.46%	4.22%	5.36%	4.22%
Non-whole grain breads, cereal, rice, pasta, and snacks (including frozen breads)	31.64%	30.50%	32.70%	76.20%	76.18%	76.20%
Vegetables						
all potato products	11.42%	7.85%	7.79%	7.93%	10.98%	7.93%
dark green vegetables	18.34%	21.25%	22.28%	7.81%	6.14%	7.81%
other vegetables	39.02%	35.06%	33.57%	52.07%	54.85%	52.07%
deep yellow vegetables	9.70%	9.70%	7.90%	3.63%	3.73%	3.63%
dry and canned beans, lentils, peas (legumes)	21.52%	26.14%	28.46%	28.56%	24.30%	28.56%
Fruit						
whole fruits	84.44%	83.19%	89.97%	67.94%	64.82%	67.94%

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fruit juices	15.56%	16.81%	10.03%	32.06%	35.18%	32.06%
Milk						
whole milk, yogurt, cream	8.10%	3.43%	3.37%	67.26%	67.97%	67.26%
low fat and skim milk, lowfat yogurt	77.61%	90.57%	86.40%	14.48%	15.50%	14.48%
all cheese (including cheese soup & sauce)	9.35%	4.00%	5.03%	25.20%	28.37%	25.20%
milk drinks and milk desserts (including dry mix and soy based drinks)	4.94%	2.00%	5.19%	31.48%	32.49%	31.48%
Meat and Meat Alternatives						
beef, pork, veal, lamb, game	33.34%	25.09%	27.78%	42.76%	44.60%	42.76%
chicken, turkey, game birds	17.70%	31.63%	14.10%	16.25%	24.88%	16.25%
fish and fish products	20.63%	27.26%	39.81%	26.50%	11.64%	26.50%
bacon, sausages, luncheon meats (including spreads)	3.78%	1.84%	3.03%	9.12%	11.95%	9.12%
nuts and nut butters & seeds	22.98%	13.37%	14.52%	2.75%	3.02%	2.75%
eggs and egg mixtures	1.57%	0.82%	0.76%	2.61%	3.91%	2.61%
Other Foods						
table fats, oils and salad dressings	15.34%	20.43%	20.66%	7.95%	8.06%	7.95%
gravies, sauces, condiments, spice, salt	12.63%	17.38%	20.27%	7.75%	8.10%	7.75%
coffee, tea	2.00%	1.53%	0.93%	1.37%	2.01%	1.37%
soft drinks, sodas, fruit drinks (including rice beverage)	42.96%	23.81%	27.51%	50.80%	50.79%	50.80%
sugars, sweets, candies	12.59%	7.36%	10.21%	21.85%	19.85%	21.85%
soups - RTS and condensed	9.92%	21.05%	15.61%	5.46%	6.09%	5.46%
soups - dry	1.98%	1.81%	2.50%	0.78%	0.73%	0.78%

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frozen or refrigerated Entrees (including pizza, fish sticks, frozen meals)	2.59%	6.64%	2.30%	4.05%	4.37%	4.05%
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