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AN ALGORITHM FOR COMPUTING A MOCK CPI FOOD COMPONENT FROM FUTURES PRICES

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Each month, the United States Department of Agriculture (USDA) forecasts the annualized rate of increase in the retail food component of the Consumer Price Index (CPI) for the coming quarter and year. Frequently, the projected changes in retail food prices diverge from anticipated movements in agricultural commodity prices, making it difficult for analysts unfamiliar with retail food prices to understand the linkage between agricultural commodity prices and retail food prices. The procedure described here is designed to illustrate these linkages by computing a mock CPI food component forecast from commodity futures prices and forecasts of general inflationary trends. The procedure is not designed to supplant USDA's more thorough forecasting procedures, but it should help analysts familiar with the commodity price outlook understand how expected commodity price changes interact with expected changes in the cost of marketing food to determine the retail food price forecast.

I. THE FOOD COMPONENT OF THE CPI

Food items comprise approximately 18 percent of the expenditures reflected in the CPI. The food component of the CPI can, in turn, be decomposed into its major groups, as shown in Table 1. Meat and dairy products make up almost half of the value of food eaten at home and more than half of the value of food prepared outside the home [Salathe and Boehm; 1979, Table 10]. The relative importance of the food groups in the CPI is fairly stable but does vary over time as food prices and consumers' tastes and incomes change.

TABLE 1

RELATIVE IMPORTANCE OF SELECTED FOOD GROUPS
IN THE CPI AS OF DECEMBER 1979

	Relative Importance as of Dec. 1979 (%)	Relative Importance within the Food-at-Home Component (%)
TOTAL CPI	100.000	
I. Nonfood items	82.343	
II. Food items	17.657	
A. Food away from home	5.454	
B. Food at home	12.203	100.000
1. Meat	4.189	34.328
a. Lamb, luncheon meat, etc.	.536	4.392
b. Beef	1.814	14.865
c. Pork	.826	6.769
d. Poultry	.392	3.212
e. Fish and seafood	.395	3.237
f. Eggs	.226	1.852
2. Dairy	1.642	13.456
3. Cereal and bakery	1.518	12.440
4. Fruits and vegetables	1.702	13.947
5. Sugar and Sweets	.418	3.425
6. Fats and oils	.346	2.835
7. Nonalcoholic beverages	1.375	11.268
8. Other food at home	1.013	8.301

SOURCE: Pat Jackman, Bureau of Labor Statistics, 202-272-5160.

Within each domestically produced food group, the retail cost can be broken into a share attributed to the cost of commodities purchased from American farmers and a portion attributed to the cost of marketing (processing, storing, handling, etc.). The cost of marketing dominates, accounting for over 60 percent of the retail cost of domestically grown food. The American farmers' share, just under 40 percent overall, varies widely between food groups (see Table 2). The farmers' share is higher than average for meat, dairy, and egg products and lower than average for most fruit, vegetable, and grain products. The farmers' share of the retail price of a given food item also fluctuates over time as commodity prices and marketing costs change nonproportionally.

The 18 percent share of food in the total CPI and the 40 percent farmers' share of the retail price of (domestically grown) food reduce the impact of commodity price fluctuations on the total CPI. A 10 percent rise in all domestically grown commodity prices, for example, would add fewer than 0.72 percentage points to the overall CPI,[1/] assuming no change in the marketing costs or in the cost of imported food.

TABLE 2

FARM VALUE AS PERCENT OF RETAIL
VALUE OF DOMESTICALLY PRODUCED FOOD ITEMS, 1979

	%
1. Market basket*	37.9
2. Meat products	52.3
a. Beef	62.0
b. Pork	46.0
3. Dairy products	52.4
4. Poultry	50.0
5. Eggs	69.0
6. Cereal and bakery products	15.4
7. Fresh fruits	28.1
8. Fresh vegetables	26.2
9. Processed fruits and vegetables	18.9
10. Fats and oils	34.6

*An index of domestically produced, farm-originated foods.

SOURCE: Agricultural Outlook, Nov., 1980, pp. 32-33.

II. MOCK CPI FOOD COMPONENT

Commodity price movements may seem very volatile and very worrisome to macroeconomists concerned with controlling inflation, especially if they are not familiar with the linkages between commodity prices and the CPI that were described in the previous section. To help analysts trace the implications for the CPI of commodity price forecasts, a simple procedure for calculating a mock CPI food component has been developed. The procedure combines forecasts of commodity prices and marketing costs with approximate farmers' shares and CPI weights to produce an estimated percentage change in the retail price of all food items as well as certain individual food groups. The elements of the procedure and the algorithm for combining them are described and interpreted below.

A. Commodity Price Forecasts

A complete algorithm would require a comprehensive set of farm-level commodity price forecasts. All important food commodities would be included in the forecast, either individually or as part of a multicommodity index. The forecasts would be for farm-level prices so that they could be weighted by the estimated farmers' share of the retail price when computing their impact on the CPI.

Since comprehensive forecasts of farm-level prices are difficult to obtain, the algorithm developed here is not complete in the sense described above. It omits food groups (notably fruits and vegetables and food away from home) and uses as forecasts of future farm prices the current values of commodity futures contracts that are tied to future cash prices at terminal markets instead of the farm gate.

The procedure for estimating future rates of change in farm prices from current futures prices is simple. If futures contracts for delivery in two adjacent future months are available, the farm-level rate of change for the intervening month is set equal to the rate of change in the futures prices. That is, if P_m (Oct.) and P_m (Nov.) denote the futures prices for delivery in October and November, respectively, and P_f (Oct.) and P_f (Nov.) denote the corresponding farm prices, set

$$\Delta\ P_f\ (\text{Oct.}) \equiv \frac{P_f(\text{Nov.})}{P_f(\text{Oct.})} = \frac{P_m(\text{Nov.})}{P_m(\text{Oct.})}$$

If adjacent futures prices are not available, interpolate between them exponentially (i.e., assume a constant multiplicative rate of change) so that, for example,

$$\Delta\ P_f(\text{Dec.}) = [P_m(\text{Mar.})/P_m(\text{Nov.})]^{1/4}.$$

Monthly rates of change can be calculated in this manner up to the most distant month for which a futures contract is currently traded.

The convenience and simplicity of the calculation of expected farm price changes from futures prices must be weighed against the errors it introduces, four of which are discussed below. First, controversy persists concerning the relationship between current futures contract prices and the expected value of future cash prices. The view taken here is that a futures price is highly correlated with the expected value of future cash prices of the commodity which can be delivered against the contract. For the purpose of illustrating the link between commodity prices and the CPI, futures prices will be regarded as commodity prices forecasts. No other commodity price forecast of comparable quality and detail can be obtained so regularly and easily.

Second, some difficulties arise from the fact that futures prices, if they are to be regarded as forecasts at all, should be thought of as forecasts of future prices at terminal markets rather than of future prices received by farmers. Let P_m be the price of a commodity at a terminal market where delivery is made against the futures contract; let P_f be the price paid to farmers for the same commodity; and let technology and competition establish a market margin whose linear approximation is $P_m - P_f = a + bP_f$. In this case $P_m = a + (1+b)P_f$, and P_m and P_f will be perfectly (nearly) proportional if a is zero (small). Expected percentage changes in P_f can be inferred from expected percentage changes in P_m (and hence from current futures prices) only if P_m and P_f are nearly proportional.

In fact, however, the spread between farm prices and terminal market prices includes a transportation charge which is generally not proportional to the commodity price, so a downward bias can be expected from using futures prices to calculate expected percentage changes in farm prices. If $P_m = a + (1+b)P_f$, where $a > o$ and $b > -1$, then, letting primes denote prices in the previous period,

$$\frac{P_m - P'_m}{P_m} = \frac{[a + (1+b)P_f] - [a + (1+b)P'_f]}{[a + (1+b)P_f]} = \frac{(1+b)[P_f - P'_f]}{a + (1+b)P_f} < \frac{P_f - P'_f}{P_f}$$

That is, the percentage change in futures prices is less than the percentage change in farm prices. This downward bias in the estimated rate of change could be partially corrected by calculating and subtracting from the futures prices an historical average of the delivery-week farm-to-futures price spread for each contract and each delivery month. That has not been attempted here.

Third, the horizon over which futures contracts are trading at any moment varies between commodities. Futures contracts for sugar, for example, extend out almost 20 months into the future. Contracts for eggs, on the other hand, are available only about 3 months ahead, which is why eggs have been omitted from the algorithm. The other commodities fall somewhere in between. Of the commodities included in the algorithm, poultry, as represented by the frozen fresh broiler contract, has the shortest horizon of futures contracts. Frozen fresh broiler contracts are available about one year ahead. If, however, the algorithm is set to run beyond the most distant contract for any commodity, the algorithm uses the assumption that beyond that most distant contract both the farm price and the retail price of the commodity will change at the same rate as the rate of change of the GNP deflator.

Fourth, as mentioned above, a set of futures contracts covering all food commodities does not exist. Nonetheless, contracts related to such major food items as beef, pork, poultry, coffee, sugar, flour, and oil are reported in the business press. These futures prices, plus information on the milk support price, are the commodity prices reflected in the algorithm described here. Potatoes, cocoa, and orange juice may be added later. Appendix 1 provides details about the futures contracts that are included in the algorithm, while Appendices 2 and 3 describe how the farmers' share and CPI relative importance weights were adjusted for the missing commodities. The most important gaps in the commodity coverage are eggs (omitted unless a price forecast is available from USDA or other sources); fruits and vegetables (omitted); food away from home (omitted); lamb, luncheon meat, and miscellaneous red meat (assumed to move as a weighted average of pork and beef); and fish and seafood (assumed to move as a weighted average of pork and poultry). Unless otherwise noted, the "total food" price index computed by the algorithm should be thought of as all food prepared at home, less eggs and fruits and vegetables, subject to the assumptions about lamb, luncheon meat, miscellaneous red meat, fish, and seafood that are given in detail in Appendix 3.

B. Marketing Costs

USDA computes a "marketing bill" for food, which attributes the difference between the retail and farm value of domestically produced food to the costs of labor, packaging materials, rail and truck transportation, corporate profits before taxes, and a number of other categories (see Table 3). The marketing bill represents over 60 percent of the retail value of domestically produced food, so predicting it accurately is very important for forecasting changes in the CPI. Because the marketing bill consists of so many unrelated components, it would be very difficult to forecast each one separately and then form a weighted average. Instead, the conformation of the marketing bill is taken to be similar to the conformation of all production activities in the U.S. economy, so that a forecast of aggregate nominal price changes can be used to estimate future changes in the cost of marketing food.

TABLE 3:

COST COMPONENTS OF THE MARKETING BILL FOR FARM FOODS, 1979*

Component	$billion	% of total
Labor	73.7	44.8
Packaging materials	18.5	11.2
Rail and truck transportation	12.2	7.4
Corporate profit before taxes	10.1	6.1
Residual**	50.0	30.4
TOTAL	164.5	100.0

*Preliminary

**Includes business taxes; depreciation; net rent; advertising; repairs, bad debts, contributions; net interest; food service in schools, colleges, hospitals, and other institutions; utilities and fuel; other.

SOURCE: 1979 from Leland Southard, USDA Economics and Statistical Services, Washington, D.C. (telephone 447-6860). For earlier years and more detailed footnotes see Salathe and Boehm (1979, Table 6).

The particular forecast of aggregate, nominal price changes used in the algorithm described here is the gross national product (GNP) deflator from a quarterly vector-autoregressive (VAR) time-series model of the U.S. economy which is maintained by the Federal Reserve Bank of Minneapolis. Quarterly forecasts of the annualized rate of change in the GNP deflator are conditioned on an information set which does not include any direct measure of prices or quantities in the food and agricultural sector of the economy. Thus, the GNP deflator forecasts from the VAR model are free of explicit double counting; changes in forecasted farm prices do not (directly) affect the marketing cost forecasts. Given lagged responses of wages, packaging costs, etc., to farm prices, this lack of spillover from agriculture to the VAR's GNP forecast seems acceptable.

The VAR's GNP deflator forecasts are converted to a monthly rate of change that is assumed constant throughout the quarter. For example, the monthly rate for July, August, and September is the twelfth root of the forecasted annualized rate of growth of the GNP deflator in the third quarter.

C. Farmers' Share and CPI Relative Importance Weights

If CPI relative importance weights were available for each member of a comprehensive set of retail food price forecasts, it would be straightforward to apply them. Similarly, if each retail food item were made from just one domestically produced commodity for which a farm share number were available, there would be no need for comment. In fact, of course, the algorithm's set of retail food price forecasts is not comprehensive (some retail food prices aren't included) and individual foods are made from several domestic and imported commodities. The result, as indicated above, is that some food items are omitted from the algorithm (eggs and fruits and vegetables, unless otherwise noted), while others (lamb, luncheon meat, other red meat, and fish and seafood) are represented as weighted averages of included items. Appendices 2 and 3 provide the details.

D. The Algorithm

The algorithm projects the rate of change in the retail price of each of the following: bakery products, fats and oils, poultry, sugar and sweets, nonalcoholic beverages, beef, pork, dairy products, and a weighted average of these items.[2/] The retail price projections for each individual commodity are a weighted average of the rate of change in farm prices for the raw materials (as estimated from futures prices) and the rate of change in marketing costs (as estimated from the GNP deflator forecasts), where the weights are the farmers' share and one minus the farmers' share, respectively. The aggregate index, representing all food prepared at home except eggs and fruits and vegetables, is a weighted average of the individual retail food price projections, where CPI relative importance percentages are used to calculate the weights (see Appendix 3).

The following notation will be used to describe the algorithm more precisely:

s_j = farmers' share of retail value of the j^{th} food item, in some base period $t=t_o$, where $j=1, 2, \ldots, n$.

w_j = relative importance of the j^{th} food item within the group of included food items. Calculated from the CPI relative importance weights as described in Appendix 3.

$d_{j,t}$ = forecasted monthly rate of change in the farm price of the raw materials for the j^{th} food item in the t^{th} month after the base period, $t=1, 2, \ldots$. Except for milk, these are calculated from futures prices as described in the text above and Appendix 1, or set equal to M_t beyond the most distant futures contract. The rate of change in the farm price of milk is set equal to the monthly rate of change in the dairy support price.

m_t = forecasted monthly rate of change in marketing costs (for all food items) in the $t^{\underline{th}}$ month after the base period. Calculated from the VAR's GNP deflator forecasts, as described in the text above.

$A_{j,t}$ = forecasted percentage change in farm price of raw materials for the $j^{\underline{th}}$ commodity, from the base period through the $t^{\underline{th}}$ month after the base period.

M_t = forecasted percentage change in the cost of marketing food items, from the base period through the $t^{\underline{th}}$ month after the base period.

$R_{j,t}$ = forecasted percentage change in the retail price of the $j^{\underline{th}}$ food item, from the base period through the $t^{\underline{th}}$ month after the base period.

D_t = a weighted average of the $d_{j,t}$'s; i.e., a forecasted average monthly rate of change in farm prices of all food raw materials included in the algorithm, in the $t^{\underline{th}}$ month after the base period.

A_t = a weighted average of the $A_{j,t}$'s; the forecasted average percentage change in farm prices of all raw materials included in the algorithm, from the base period through the $t^{\underline{th}}$ month after the base period.

R_t = a weighted average of the $R_{j,t}$'s; the forecasted average percentage change in the retail prices of all food items included in the algorithm.

The algorithm proceeds through the following calculations:

1. $A_{j,t} = 100 \left[\left(\prod_{i=1}^{t} d_{j,i}\right) - 1\right]$

2. $M_t = 100 \left[\left(\prod_{i=1}^{t} m_i\right) - 1\right]$

3. $R_{j,t} = (s_j)(A_{j,t}) + (1-s_j)(M_t)$

4. $D_t = \sum_{j=1}^{n} (d_{j,t})(w_j)$

5. $A_t = \sum_{j=1}^{n} (A_{j,t})(w_j)$

6. $R_t = \sum_{j=1}^{n} (R_{j,t})(w_j) = \sum_{j=1}^{n} \{[(s_j)(A_{j,t}) + (1-s_j)(M_t)](w_j)\}$

The algorithm then tabulates $d_{j,t}$, m_t, $A_{j,t}$, M_t, and $R_{j,t}$, for each commodity ($j=1, 2, \ldots, n$) and for as many time periods as are included in the forecast. The algorithm also tabulates the aggregates D_t, A_t, M_t, and R_t. The aggregates A_t, M_t, and R_t are plotted against time; similar plots of $A_{j,t}$, M_t, and $R_{j,t}$, for any individual food item can be selected by the user.

1/ 0.72 = 0.1 x 0.4 x .18. This figure overstates the impact on the CPI of a 10 percent rise in domestically produced commodities in at least two ways. First, about 10 percent of grocery store food sales are of items not produced in the U.S. [Salathe and Boehm; 1979, p. 1]. Second, the 0.18 share for food items in the CPI includes the 0.05 share for food away from home, for which the farmers' share is below 0.4.

2/ Prices of lamb, luncheon and other red meat, and fish and seafood are included in the weighted average as weighted averages of the beef, pork, and poultry prices. See Appendix 3 for details.

Appendix 1: Futures Contracts Chosen to Represent the Farm Prices of Raw Materials

Retail food item	Corresponding futures contract	Contract months	Corresponding cash markets, if any	Currently in algorithm?	Contracts extend at least one year into the future?
Cereal and bakery	Wheat (CBT)	Mar., May, July, Sept., Dec.		yes	yes
Fats and oils	Soybean oil (CBT)	Jan., Mar., May, July, Aug., Sept., Oct., Dec.	crude soybean oil, Decatur	yes	yes
Sugar and sweets	World sugar, #11 (CSCE)	Mar., May, July, Sept., Dec.	raw sugar cane, New York	yes	yes
Nonalcoholic beverages	a. Coffee (CSCE) b. Cocoa (CSCE)	Mar., May, July, Sept., Dec. Mar., May, July, Sept., Dec.		yes no	yes yes
Beef	Midwestern live cattle (CME)	Jan., Feb., Apr., June, Oct., Dec.	Choice steers, Omaha, avg. cwt.	yes	yes
Pork	Live hogs (CME)	Feb., Apr., June, July, Aug., Oct., Dec.	hogs, Omaha, avg. cwt.	yes	yes
Poultry	Frozen fresh broilers (CME)	Feb., Apr., June, July, Aug., Oct., Dec.	dressed "A" broilers, New York	yes	Not in all months
Dairy products	None; USDA milk support price	support price is currently revised in April and Oct. The rate of change is zero except in these months.		yes yes	Forecasts available from USDA/ERS.
Eggs	Shell eggs (CME)	Jan. through Dec.		no	no
Fruits and vegetables	a. Frozen concentrated orange juice (NYCE)	Jan., Mar., May, July, Nov.	frozen concentrated orange juice, New York	no	yes
	b. Russet potatoes (CME)	Jan., Mar., May, Nov.		no	no

Appendix 2: Farmers' share proportions, r_j for j= 1, 2, . . ., 11

1.	Beef	.62
2.	Pork	.46
3.	Poultry	.537
4.	Eggs	.681
5.	Dairy	.524
6.	Bakery and cereals	.148
7.	Total fruits and vegetables	.25 1/
8.	Fats and oils	.24
9.	Sugar	.5 2/
10.	Nonalcoholic beverages	.5 3/
11.	Other food at home	.4 4/
12.	Food away from home	.25 5/

SOURCE: Dennis Dunham, USDA/ESCS/NED/EIS, (202)447-8801, unless otherwise noted. His figures are for 1979 average and many appear in Agricultural Outlook.

1/ Rough "average" of fresh fruit (.287), fresh vegetables (.297), and processed fruit and vegetables (.189)

2/ For domestic sugar, Dunham says .4 to .45. Rounded to .5 because much sugar is imported at higher levels of processing, and futures quotation is in terms of sugar, not canes or beets.

3/ Just a guess at share of coffee bean price in retail coffee price.

4/ Equals overall farmers' share in market-basket items.

5/ Based, loosely, on Salathe and Boehm (1979, page 11).

Appendix 3: Relative importance weights; w_j, for j=1, 2, . . ., 12

Food item	Relative importance in CPI	Relative importance adjusted for gaps in commodity coverage		Weight w_j in algorithm; or column 3÷9.144
1. Lamb, luncheon, and other red meat	.536	(see beef and pork)	0.0	0.0
2. Beef	1.814	$\text{beef} + \frac{\text{beef}}{\text{beef + pork}}$ (lamb, etc.) $= 1.814 + \frac{1.814}{2.64}(.535) =$	2.18	.238408
3. Pork	.826	$\text{pork} + \frac{\text{pork}}{\text{beef + pork}}$ (lamb, etc.) $+ \frac{\text{pork}}{\text{pork + poultry}}$ (fish and seafood) $= .826 + \frac{.826}{2.64}(.535) + \frac{.826}{1.218}(.395) =$	1.26	.137795
4. Poultry	.392	$\text{poultry} + \frac{\text{poultry}}{\text{pork + poultry}}$ (fish and seafood) $= \frac{.392}{1.218}(.395) =$	.405	.044291
5. Fish and seafood	.395	(see pork and poultry)	0.0	0.0
6. Eggs	.226		0.0	0.0
7. Dairy	1.642		1.642	.179571
8. Cereals and bakery	1.518		1.518	.166010
9. Fruits and vegetables	1.702		0.0	0.0
10. Sugar and sweets	.418		.418	.045713
11. Fats and oils	.346		.346	.037839
12. Nonalcoholic beverages	1.375		1.375	.150372
13. Other food at home	1.013		0.0	0.0
14. Food away from home	5.454		0.0	0.0
15. TOTAL	17.657		9.144	.999999