The Implications of Offsetting Adjustments in Government Purchase Prices for Butter and Nonfat Dry Milk

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Abstract. *Commodity Credit Corporation (CCC) purchases of milkfat have greatly exceeded CCC purchases of nonfat milk solids on a milk-equivalent basis since 1988 USDA has responded by reducing the purchase price of butter and increasing the purchase price of nonfat dry milk twice in 1990 and twice in 1992 This article examines the effects of changing the relative purchase prices of butter and nonfat dry milk on CCC dairy product purchases and dairy program costs The results indicate that balancing CCC purchases of milkfat and nonfat solids on a milk-equivalent basis and minimizing CCC dairy product purchase costs lead to nearly the same dairy program costs*

Keywords. *Butter, dairy program costs, milk, nonfat dry milk, price support*

Cow's milk averages about 3 67-percent butterfat, 8 60-percent nonfat solids, and 87 73-percent water although butterfat and nonfat solids content varies seasonally and by breed (Goold, 1982) [1] The Commodity Credit Corporation (CCC) supports the price of milk used in manufacturing by purchasing butter, cheese, and nonfat dry milk Butter chiefly consists of milkfat, and nonfat dry milk primarily consists of nonfat solids, while the manufacture of cheese utilizes nonfat solids and milkfat in nearly the same proportions as those in cow's milk

Butter and nonfat dry milk are joint products This allows the CCC to reduce the butter purchase price and offset the decline with an equivalent increase in the purchase price of nonfat dry milk and not change the underlying support price for manufacturing milk CCC's operating objective is to make offsetting adjustments in the purchase prices of butter and nonfat dry milk until purchases of milkfat and nonfat milk solids are in approximately the same proportion as their presence in cow's milk This means that the CCC will continue to make offsetting adjustments in purchase prices until purchases of milkfat and nonfat milk solids are equal on a milk equivalent basis [2] The U S Department of Agriculture (U S Dept Agr , ASCS, 1991a) states that "Achieving this goal eliminates program-caused inequities that affect the competitive situation between plants Also, additional farm milk and product price stability can be expected when CCC purchase prices are in alignment with market demands "

CCC purchases of nonfat solids, milk equivalent basis, averaged about 27 percent more than CCC purchases of milkfat, milk equivalent basis, during 1980-88 In contrast, CCC purchases of milkfat totaled 9 4 billion pounds milk equivalent in 1989, while purchases of nonfat solids were below 1 billion pounds milk equivalent In response to the large imbalance in CCC purchases of milkfat and nonfat solids, USDA lowered the purchase price of butter and increased the purchase price of nonfat dry milk by an equivalent amount twice in 1990 However, CCC purchases of milkfat continued to exceed greatly purchases of nonfat solids following these two adjustments In 1991, CCC purchases of milkfat were 2 6 times greater than purchases of nonfat solids on a milk equivalent basis, prompting USDA to reduce the purchase price of butter by 11 cents per pound and raise the CCC purchase price of nonfat dry milk by 6 cents per pound twice in early 1992 [3] These offsetting adjustments in the purchase prices of butter and nonfat dry milk, each equivalent to 50 cents per 100 pounds of milk, were similar to previous adjustments that became effective in 1990

There may be other reasons for making offsetting adjustments in the purchase prices of butter and

Salathe is an agricultural economist with USDA's Economic Analysis Staff The author thanks Don Blayney, John Mengel, J Michael Price, and Mark Weimar for helpful comments

[1]Sources are listed in the References section at the end of this article

[2]Milk equivalents measure how much cow's milk is needed to produce 1 pound of a dairy product Since dairy products contain different relative proportions of milkfat and nonfat solids, milk equivalents are calculated both on a milkfat and nonfat solids basis For example, suppose that a dairy product consists of 10-percent milkfat and 10-percent nonfat solids Thus, it would take 2 72 (10/3 67) pounds of cow's milk on a milkfat basis and 1 16 (10/8 6) pounds of cow's milk on a nonfat solids basis to produce 1 pound of the dairy product

[3]The $1 00 per hundredweight (cwt) of milk adjustment in butter and nonfat dry milk purchase prices in 1992 also raised the cheese purchase price by $0 0075 per pound or by 0 68 percent compared with a 22 4-percent decrease in the purchase price for butter and a 14 5-percent increase in the purchase price of nonfat dry milk Because of the small relative adjustment, this paper does not address changes in the cheese purchase price

nonfat dry milk besides balancing CCC purchases of milkfat and nonfat milk solids for the purpose of providing product price stability The Food, Agriculture, Conservation and Trade Act of 1990 gives the Secretary of Agriculture the authority to adjust CCC purchase prices for butter and nonfat dry milk in order to lower the cost of the dairy price support program or achieve other objectives (U S Congress, 1990) Thus, it would appear that Congress viewed offsetting adjustments in purchase prices as a way to reduce dairy program costs and not just as a means of stabilizing product prices

Balancing CCC purchases of milkfat and nonfat milk solids on a milk equivalent basis may best accomplish the multiple objectives of the dairy price support program, such as stability, minimum market interference, equity between butter-powder and cheese plants, and low taxpayer cost Setting butter and nonfat dry milk purchase prices on a basis other than equalizing CCC purchases may be inconsistent with the overall objectives of the price support program However, it still seems reasonable to compare the relative outcomes of different rules for setting butter and nonfat dry milk prices, especially given the emphasis in current legislation on minimizing CCC costs

This article examines the implications for dairy program costs, CCC purchases of butter and nonfat dry milk, prices of butter and nonfat dry milk, and butter and nonfat dry milk consumption of two decision rules for setting butter and nonfat dry milk CCC purchase prices The first decision rule is to balance CCC purchases of milkfat and nonfat milk solids on a milk equivalent basis and the second is to minimize the cost of the dairy price support program The article begins by deriving mathematically the offsetting adjustments in the purchase prices of butter and nonfat dry milk implied by each decision rule Next, equations are developed for changes in demand for milkfat and nonfat solids that account for offsetting adjustments in butter and nonfat dry milk purchase prices Last butter and nonfat dry milk purchase prices, butter and nonfat dry milk purchases, and CCC outlays for the dairy program are calculated for each decision rule and compared to actual values for 1991

The mathematical model does not consider changes in milk production, milk prices, and production of dairy products While offsetting adjustments do not change the underlying support price for manufacturing milk, returns of butter/powder manufacturing plants could be affected if market prices for butter or nonfat dry milk greatly exceed their CCC purchase prices A change in returns of butter/powder manufacturing plants would be expected to have some impact on milk prices, milk production, and production of dairy products However, the difference in milk equivalent purchases of milkfat and nonfat solids would not be affected by changes in either the level of milk production or the level of butter/powder production This is because total milk equivalents of both milkfat and nonfat solids available for processing or used in butter/powder production would change by the same amount Thus, changes in milk production and production of butter/powder should not change the offsetting adjustment in purchase prices needed to balance CCC purchases of milkfat and nonfat solids

Our model assumes that exports of dairy products would not be affected by offsetting adjustments in CCC purchase prices of butter and nonfat dry milk It further assumes that the relative proportions of milkfat and nonfat solids used to produce individual dairy products do not change These assumptions become more questionable when large adjustments in prices are projected

Balancing CCC Purchases

If the decision rule is to balance CCC purchases, offsetting adjustments in the purchase prices of butter and nonfat dry milk will occur until CCC purchases of milkfat and nonfat milk solids are equal on a milk equivalent basis An offsetting change in CCC purchase prices of butter and nonfat dry milk is given by

$$\Delta P_B = -8\ 13\Delta P_{NF}/4\ 48, \qquad (1)$$

where ΔP_B denotes the change in the purchase price of butter, and ΔP_{NF} is the change in the purchase price of nonfat dry milk The coefficients in equation 1 represent the number of pounds of butter (4 48) and nonfat dry milk (8 13) obtainable from 100 pounds of milk that is used to establish the purchase prices of butter and nonfat dry milk (U S Dept Agr , ASCS, 1991c)

Milk equivalent purchases on a milkfat and nonfat milk solids basis can be expressed as

$$ME_B = 21\ 8AC_B, \qquad (2)$$

$$ME_{NF} = 11\ 64AC_{NF}, \qquad (3)$$

where ME_B is the milk equivalent on a milkfat basis, ME_{NF} is the milk equivalent on a nonfat solids basis, AC_B is butter purchases, and AC_{NF} is nonfat dry milk purchases (U S Dept Agr , ASCS, 1991b) The milk equivalent of milkfat and nonfat milk solids purchases are affected by cheese

purchases In addition, nonfat dry milk contains a small amount of milkfat, and butter contains a small amount of nonfat milk solids Nevertheless, equations 2 and 3 closely approximate the change in milk equivalent purchases on a milkfat and nonfat milk solids basis, since the milk equivalent factors used for cheese closely reflect whole milk and butter and nonfat dry milk contain only very small (1 percent or less) amounts of nonfat milk solids and milkfat, respectively These equations indicate that it takes, on average, 21 8 pounds of milk to obtain 1 pound of butter and 11 64 pounds of milk to obtain 1 pound of nonfat dry milk

CCC purchases of butter and nonfat dry milk, after an offsetting adjustment in the CCC purchase prices of butter and nonfat dry milk, can be expressed in terms of changes in milkfat and nonfat solids consumption and the initial purchases of butter and nonfat milk solids These equations are as follows

$$AC_B = \underline{AC}_B - \Delta D_B/8, \tag{4}$$

$$AC_{NF} = \underline{AC}_{NF} - \Delta D_{NF}/1\ 0, \tag{5}$$

where $\underline{AC}_B$ represents the initial purchases of butter, $\underline{AC}_{NF}$ represents the initial purchases of nonfat dry milk, ΔD_B is the change in the quantity demanded of milkfat, and ΔD_{NF} is the change in the quantity demanded of nonfat solids The changes in the quantities demanded of milkfat and nonfat solids are divided by factors that convert milkfat and nonfat milk solids into butter and nonfat dry milk, respectively

We express the demand for milkfat as a function of the purchase price of butter and the demand for nonfat solids as a function of the purchase price of nonfat dry milk

$$D_B = BP_B^{-\beta}, \tag{6}$$

$$D_{NF} = AP_{NF}^{-\alpha}, \tag{7}$$

where α and β are the elasticities of demand for nonfat milk solids and milkfat, respectively We link these two demand functions to changes in CCC purchases by using the following identities

$$\Delta D_B = D_B - \underline{D}_B, \tag{8}$$

$$\Delta D_{NF} = D_{NF} - \underline{D}_{NF}, \tag{9}$$

$$\Delta P_B = P_B - \underline{P}_B, \tag{10}$$

$$\Delta P_{NF} = P_{NF} - \underline{P}_{NF}, \tag{11}$$

where $\underline{D}_B$ and $\underline{D}_{NF}$ are the initial quantities of milkfat and nonfat solids consumed, respectively, and $\underline{P}_B$ and $\underline{P}_{NF}$ are the initial purchase prices of milkfat and nonfat solids, respectively Underlined variables are exogenous or predetermined

To derive the purchase prices of butter and nonfat dry milk that balance CCC purchases, we set equations 2 and 3 equal to one another and solve the above system of equations Solving this system of equations for P_{NF} yields the following equation

$$\begin{aligned} 11\ 64\underline{AC}_{NF} + 11\ 64\underline{D}_{NF} - 21\ 8\underline{AC}_B \\ - (21\ 8/8)\underline{D}_B = 11\ 64AP_{NF}^{-\alpha} \\ - (21\ 8/8)B(-8\ 13\ (P_{NF} \\ - \underline{P}_{NF})/4\ 48 + \underline{P}_B)^{-\beta}, \end{aligned} \tag{12}$$

which expresses the price of nonfat dry milk that balances CCC purchases of milkfat and nonfat solids as a nonlinear function of the initial purchases of butter and nonfat dry milk, the initial consumption of milkfat and nonfat solids, the initial prices of nonfat dry milk and butter, and the elasticities of demand for milkfat and nonfat milk solids Once equation 12 is solved, equations 1 and 11 can be used to solve for the price of butter that balances CCC purchases

Minimizing CCC Outlays

An alternative decision rule would be to make offsetting adjustments in the CCC purchase prices of butter and nonfat dry milk in order to minimize CCC dairy product purchase costs The cost minimization problem can be written as follows

$$\begin{aligned} \text{MIN } C = P_{NF}(\underline{AC}_{NF} - \Delta D_{NF}) \\ + P_B\ (\underline{AC}_B - \Delta D_B/8), \end{aligned} \tag{13}$$

where all terms have been defined earlier [4] By substituting, we obtain

$$\begin{aligned} \text{MIN } C = P_{NF}\ (\underline{AC}_{NF} - (AP_{NF}^{-\alpha} - \underline{D}_{NF})) \\ + (-8\ 13\ (P_{NF} - \underline{P}_{NF})/4\ 48 + \underline{P}_B) \\ (\underline{AC}_B - (B(-8\ 13\ (P_{NF} - \underline{P}_{NF}) \\ /4\ 48 + \underline{P}_B)^{-\beta} + \underline{D}_B)/8) \end{aligned} \tag{14}$$

To determine the purchase price of nonfat dry milk that minimizes CCC dairy product purchase costs, we differentiate equation 14 with respect to P_{NF}, which leads to the following equation

[4]The minimization problem ignores the cost of storage and potential receipts that might be realized from commercial sales of CCC-held stocks of butter and nonfat dry milk in future years In most years, CCC storage costs and commercial sales of CCC-held stocks are relatively small compared with total dairy program costs

$$dC/dP_{NF} = \underline{AC}_{NF} - A(-\alpha+1)P_{NF}^{-\alpha} + \underline{D}_{NF} - 8\ 13\underline{AC}_B/4\ 48 - 8\ 13\underline{D}_B/(8*4\ 48) + [8\ 13(-\beta+1)B/(4\ 48*8)]\ [-8\ 13\ (P_{NF} - \underline{P}_{NF})/4\ 48 + \underline{P}_B]^{-\beta} \quad (15)$$

Setting equation 15 equal to zero and solving this equation for P_{NF} yields the price of nonfat dry milk that minimizes CCC purchase costs After a solution to equation 15 is found, equations 1 and 11 an be used to solve for the purchase price of butter that minimizes CCC purchase costs

Multiplying equation 15 by 11 64 and then comparing it with equation 12 reveals that the coefficients of $\underline{AC}_B$ and $\underline{D}_B$ are not identical in the two equations This is because the technical coefficients for converting CCC purchases of butter and nonfat dry milk into milk equivalents do not correspond exactly to the technical coefficients used to compute equivalent changes in CCC purchase prices This can be seen by taking the ratio of the technical coefficients in equations 2 and 3 (21 8 and 11 64) and comparing it with the ratio of the coefficients in equation 1 (8 13 and 4 48)

If we assume the ratio of the technical coefficients for determining milk equivalent purchases of butter and nonfat dry milk equals that used for determining an offsetting change in purchase prices, equations 12 and 15 are identical if α and β equal zero This result indicates that as the demand elasticities for nonfat solids and milkfat move closer to zero the offsetting change in purchase prices of butter and nonfat dry milk needed to balance purchases moves closer to the offsetting change in purchase prices that minimizes CCC purchase costs

Demand Responses for Milkfat and Nonfat Milk Solids

The above equations for the purchase prices of butter and nonfat dry milk depend on the elasticities of demand for milkfat and nonfat solids under offsetting purchase price adjustments We could compute these elasticities as simple weighted averages of the elasticities of demand for individual dairy products However, since offsetting adjustments in butter and nonfat dry milk purchase prices moves the prices of milkfat and nonfat solids in opposite directions and most dairy products contain both milkfat and nonfat solids, that approach would overstate the changes in demand for milkfat and nonfat milk solids caused by offsetting purchase price adjustments For example, a higher price for nonfat solids would, by itself, raise the price of cheese and reduce cheese consumption On the other hand, a lower price for milkfat would, by itself, reduce the price of cheese and increase cheese consumption Taking into account the changes in the prices of both milkfat and nonfat milk solids, cheese prices and consumption may change only slightly, leading to little change in the amount of milkfat or nonfat milk solids consumed in the form of cheese

To derive expressions for the elasticities of demand for milkfat and nonfat solids that account for offsetting purchase price adjustments, changes in the retail prices of individual dairy products are expressed as functions of changes in the purchase or wholesale prices of butter and nonfat dry milk Butter and nonfat dry milk wholesale prices are assumed to be directly affected by changes in their respective purchase prices This assumption may not be valid when CCC purchases are very small or nonexistent, in which case a moderate increase in the purchase price may not greatly influence wholesale prices However, even in that case a large increase in the purchase price may still lead to a sizable increase in the wholesale price These equations are as follows

$$dP_i = \underline{W}_{NF,i}dP_{NF} + \underline{W}_{B,i}dP_B/8\ i = 1, \quad ,n, \quad (16)$$

where $\underline{W}_{NF,i} = \underline{D}_{NF,i}/\underline{D}_i$, $\underline{W}_{B,i} = \underline{D}_{B,i}/\underline{D}_i$ $\underline{D}_{NF,i}$ is the quantity of nonfat solids in the ith dairy product, $\underline{D}_{B,i}$ is the quantity of milkfat in the ith dairy product, $\underline{D}_i$ is total commercial use of the ith dairy product, and dP_i is the change the retail price of the ith dairy product The changes in the prices of butter and nonfat dry milk are divided by factors that reflect the value of milkfat and nonfat solids in these products Substituting equation 1 into equation 16, we obtain the following expression

$$dP_i = \underline{W}_{NF,i}dP_{NF} - 8\ 13\underline{W}_{B,i}dP_{NF}/(8*4\ 48), \quad (17)$$

which expresses the change in the price of the ith dairy product as a function of the change in the price of nonfat dry milk and the importance of nonfat solids and milkfat in the ith dairy product

The total demand for nonfat solids can be expressed as a weighted summation of commercial use of individual dairy products Taking the derivative of total demand for nonfat solids with respect to the price of nonfat dry milk, we obtain

$$dD_{NF}/dP_{NF} = \Sigma\underline{W}_{NF,i}(dD_i/dP_i)\ (dP_i/dP_{NF}) \quad (18)$$

This equation expresses the change in consumption of nonfat milk solids caused by a change in the price of nonfat dry milk as a weighted summation of the changes in consumption of each

dairy product caused by a change in the retail price of that product multiplied by the change in the price of each product caused by the change in the price of nonfat dry milk Substituting equation 17 into equation 18, we obtain the change in nonfat solids consumption caused by a change in the price of nonfat dry milk

$$dD_{NF}/dP_{NF} = \Sigma \underline{W}_{NF,i}(dD_i/dP_i)(\underline{W}_{NF,i} - 8\ 13\underline{W}_{B,i}/(8*4\ 48)) \quad (19)$$

Further simplification and manipulation of equation 19 leads to the following expression for the elasticity of demand for nonfat solids under offsetting adjustments in purchase prices

$$\epsilon_{NF} = \Sigma \epsilon_i \underline{P}_{NF} \underline{S}_{NF,i}(\underline{W}_{NF,i} - 8\ 13\underline{W}_{B,i}/(8*4\ 48))/\underline{P}_i, \quad (20)$$

where $\underline{S}_{NF,i} = \underline{D}_{NF,i}/\underline{D}_{NF}$ The latter identity denotes the share of total nonfat solids consumption accounted for by each individual dairy product Following the same procedure, it can be shown that the elasticity of demand for milkfat under offsetting adjustments in purchase prices is as follows

$$\epsilon_B = \Sigma \epsilon_i \underline{P}_B \underline{S}_{B,i}\ (-4\ 48\underline{W}_{NF,i}/8\ 13 + \underline{W}_{B,i}/8)/\underline{P}_i, \quad (21)$$

where $\underline{S}_{B,i} = \underline{D}_{B,i}/\underline{D}_B$ These expressions for the elasticities are functions of the initial purchase prices of butter and nonfat dry milk, the retail prices of individual dairy products, the retail demand elasticities of individual dairy products, the relative share of total milkfat and total nonfat solids consumption accounted for by each dairy product, and the proportions of nonfat solids and milkfat in each dairy product

We used elasticities for individual dairy products that are based on estimates from earlier studies to derive numerical values for ϵ_{NF} and ϵ_B The chosen demand elasticity for fluid milk of −30 is very similar to those of other studies (Brandow (1961), −0 29, George and King (1971), −0 35, and Haidacher, Blaylock, and Myers (1988), −0 26) The cheese demand elasticity of −0 40 is somewhat smaller than the George and King estimate of −0 46, but higher than the Haidacher estimate of −0 33 The butter demand elasticity of −0 55 is between the Haidacher estimate (−0 17) and the George and King estimate (−0 65) as is the demand elasticity for frozen milk products of −0 35, (−0 12 and −0 52) Past studies indicate that nonfat dry milk consumption is very responsive to changes in nonfat dry milk and fluid milk prices (Salathe, Price, and Gadson, 1982) The selected demand elasticity for nonfat dry milk of −0 75 is the highest among the dairy product categories

The demand elasticities for milkfat and nonfat solids under offsetting adjustments in butter and nonfat dry milk purchase prices were computed using data for 1991, the demand elasticities for individual dairy products in table 1, and the equations derived earlier In 1991, nearly three-fourths of total milkfat consumption was in the form of fluid milk and cream and cheese and 90 percent of nonfat solids consumption was in the form of those products (tables 2 and 3) Butter accounted for 15 percent of milkfat consumption in 1991 and nonfat dry milk consumption accounted for just 5 percent of nonfat solids consumption

Substituting the base demand elasticities for dairy products in table 1 and the data in tables 2 and 3 into equations 20 and 21, we obtain −0 035 for the elasticity of demand for milkfat and −0 030 for the elasticity of demand for nonfat solids All of the change in demand for milkfat is accounted for by butter, while fluid milk and cream accounts for about 40 percent and nonfat dry milk accounts for about 50 percent of the change in demand for nonfat milk solids with offsetting adjustments in purchase prices for butter and nonfat dry milk

Alternative values for the retail demand elasticities for butter and nonfat dry milk were selected to provide an indication of the sensitivity of the results to changes in these values Increasing the butter retail demand elasticity from −0 55 to −0 65 increased the elasticity of demand for milkfat from −0 035 to −0 042 Raising the nonfat dry milk retail demand elasticity from −0 75 to

Table 1—Demand elasticities for dairy products

Product	Base	Alt 1	Alt 2	Alt 3
Fluid milk and cream	−30	−30	−30	−30
Butter	−55	−65	−55	−65
Cheese	−40	−40	−40	−40
Nonfat dry milk	−75	−75	−85	−85
Frozen milk products	−35	−35	−35	−35

Sources Brandow (1961), George and King (1971), Haidacher, Blaylock, and Myers (1988), Salathe, Price, and Gadson (1982)

Table 2—Consumption and prices of dairy products, 1991

Product	Commercial use	$\underline{W}_{B,i}$	$\underline{W}_{NF,i}$	Retail price
	Mil lbs	—Percent—		$/lb
Fluid milk and cream	58,400	2 6	9 0	0 30
Butter	908	80 0	1 0	2 00
Cheese	6,257	34 0	85 0	3 50
Nonfat dry milk	630	8	100 0	2 00
Frozen milk products	5,353	12 0	10 0	1 15

Sources U S Dept of Agr ASCS (1991b) U S Dept Agr ERS (1992b)

Table 3—Milkfat and nonfat solids consumption, by product, 1991

Product	Milkfat consumption	S_{B_i}	Nonfat consumption	S_{NF_i}
	Mil lbs	Percent	Mil lbs	Percent
Fluid milk and cream	1,518	30 2	5,256	44 7
Butter	726	14 5	9	1
Cheese	2,127	42 4	5,318	45 3
Nonfat dry milk	5	1	630	5 4
Frozen milk products	642	12 8	535	4 5
Total	5,018	100 0	11,748	100 0

Source Data calculated using information from table 2

–0 85 increased the elasticity of demand for nonfat solids from –0 030 to –0 032

Traditional estimates of the demand elasticities for milkfat and nonfat milk solids measure the effect of a change in one price, either milkfat or nonfat milk solids, while holding all other variables constant Here, we allow the prices of both nonfat milk solids and milkfat to change simultaneously and in opposite directions As a result, consumption of milkfat and nonfat milk solids should be less responsive to changes in the prices of milkfat and nonfat milk solids than those suggested by traditional demand elasticity estimates Hutton and Helmberger (1982), using an econometric model, estimated the elasticities of demand for milkfat and nonfat solids used in manufacturing Their shortrun estimate of the demand elasticity for milkfat is 4-5 times larger and their estimate of the demand elasticity for nonfat milk solids is 2-3 times larger than the corresponding elasticities we derived under offsetting adjustments in the purchase prices of butter and nonfat dry milk

Model Results

The highly nonlinear equations presented earlier were solved by a iterative search process to determine the changes in the purchase prices for butter and nonfat dry milk that would have equalized CCC purchases of milkfat and nonfat solids on a milk equivalent basis and minimized CCC purchase costs in 1991 In 1991, USDA purchased 443 million pounds of butter, 268 million pounds of nonfat dry milk, and 77 million pounds of cheese at a cost of $750 million (U S Dept Agr , ERS, 1992b) Purchases on a milkfat basis equaled 10 4 billion pounds compared with purchases of 3 9 billion pounds when computed on a nonfat solids basis CCC purchase prices for butter and nonfat dry milk were 98 cents per pound and 85 cents per pound, respectively, in 1991

The model estimates that large offsetting changes in butter and nonfat dry milk purchase prices would have been required to equalize CCC purchases of milkfat and nonfat solids on a milk equivalent basis in 1991 (table 4) The offsetting adjustment needed to balance purchases was an estimated –63 cents per pound for butter and +35 cents per pound for nonfat dry milk This adjustment would have lowered the butter purchase price by nearly two-thirds and increased the nonfat dry milk purchase price by two-fifths in 1991 These adjustments in purchase prices would have reduced CCC purchases of butter by about 55 percent, increased CCC purchases of nonfat dry milk by about 45 percent and reduced the cost of dairy product purchases by the CCC by about $125 million These results vary only slightly under the alternative elasticity estimates for milkfat and nonfat solids

Making offsetting purchase price adjustments with the objective of minimizing dairy product purchase costs would have led to a slightly higher purchase price for nonfat dry milk and a moderately lower purchase price for butter than that estimated for balancing CCC removals Thus, minimizing CCC purchase costs would have resulted in higher net removals of nonfat dry milk and lower net removals of butter than balancing removals on a milk equivalent basis Increasing the milkfat elasticity increased the disparity between the purchase prices that would have balanced purchases of milkfat and nonfat solids on a milk equivalent basis and those that would have minimized CCC purchase costs However, increasing the nonfat solids elasticity tended to reduce the disparity in the purchase prices between balancing CCC removals and minimizing CCC purchase costs

In all instances, the estimates of CCC dairy product purchase costs are nearly identical whether the objective is to minimize purchase costs or balance CCC purchases Despite significant differences in purchase prices, CCC purchase costs differ by at most $3 million between minimizing CCC purchase costs and balancing CCC purchases on a milk equivalent basis This

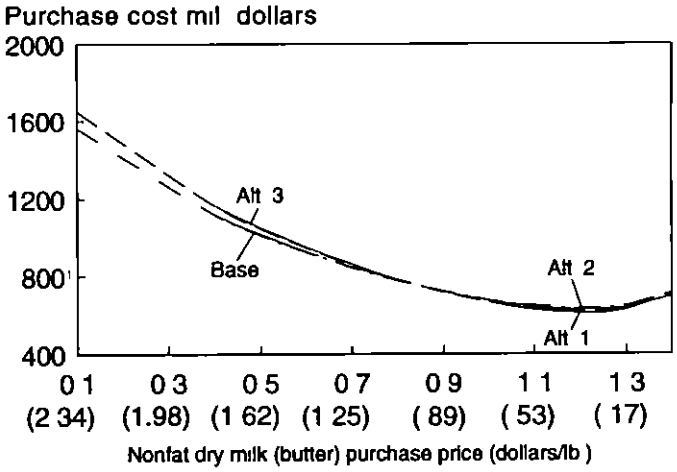
Table 4—Effects of alternative rules for setting purchase prices

Item	Units	1991 Data	Retail demand elasticities			
			Base	Alt 1	Alt 2	Alt 3
			Equalizing CCC purchases			
Butter purchase price	Dollars/lb	98	35	40	35	41
Nonfat dry milk purchase price	Dollars/lb	85	1 20	1 17	1 20	1 17
Butter purchases	Mil lb	443	208	203	212	207
Nonfat dry milk purchases	Mil lb	268	389	380	397	387
CCC purchases milkfat	Bil lb	10 4	5 3	5 2	5 4	5 2
CCC purchases nonfat	Bil lb	3 9	5 3	5 2	5 4	5 2
CCC purchase cost	Mil dol	750	627	613	636	622
			Minimizing CCC outlays			
Butter purchase price	Dollars/lb	98	30	31	33	33
Nonfat dry milk purchase price	Dollars/lb	85	1 22	1 22	1 21	1 21
Butter purchases	Mil lb	443	180	132	197	150
Nonfat dry milk purchases	Mil lb	268	396	395	400	400
CCC purchases milkfat	Bil lb	10 4	4 7	3 6	5 0	4 0
CCC purchases nonfat	Bil lb	3 9	5 4	5 3	5 4	5 4
CCC purchase cost	Mil dol	750	626	610	636	620
Milkfat elasticity			-035	-042	-035	-042
Nonfat solids elasticity			-030	-030	-032	-032

suggests that there may be a considerable range of purchase prices that would lead to nearly the same cost as minimizing CCC purchase costs

We selected various purchase prices and used equations 1-11 to examine more closely the relationship between purchase prices, CCC dairy product purchase costs, and milk equivalent purchases CCC purchase costs fall rapidly under offsetting adjustments in purchase prices as the purchase price of nonfat dry milk increases from about 10 cents per pound to about 90 cents per pound (fig 1) Over this range of purchase prices, CCC purchase costs decline from $1 7 billion to $700 million The ratio of milk equivalent purchases of milkfat to milk equivalent purchases of nonfat solids declines from over 20 to slightly over 2 pounds of milkfat per pound of nonfat solids (fig 2)

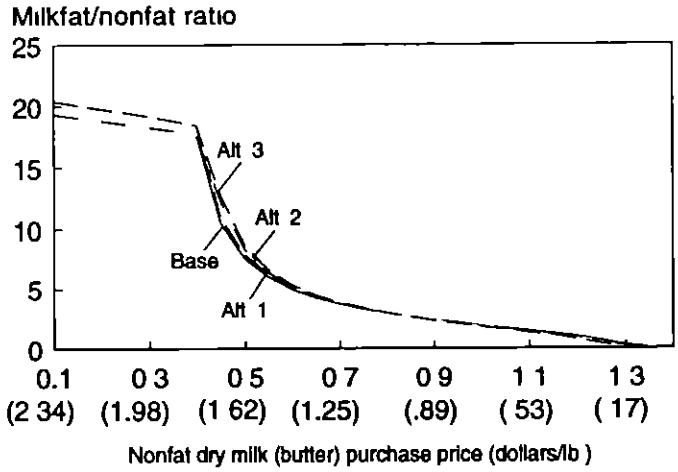
Figure 1
CCC dairy purchase costs under alternative purchase prices



In contrast, CCC purchase costs remain near $650 million when the nonfat dry milk purchase price (and butter purchase price adjusted accordingly) is in the range of $1 05 to $1 30 per pound When the purchase price of nonfat dry milk is in the range of $1 05 to $1 30 per pound, the ratio of milk equivalent purchases of milkfat to milk equivalent purchases of nonfat solids ranges from 1 73 to 0 13 pounds of milkfat per pound of nonfat solids These results indicate that CCC purchase costs are fairly stable over a fairly wide range of purchase prices and over a fairly wide range in milk equivalent purchases of milkfat and nonfat solids And, there is a considerable range in purchase prices that yield nearly the same CCC purchase costs as minimizing CCC purchase costs

The analysis may overstate the butter price decline needed to balance purchases The analysis assumes commercial export sales of butter do not increase as market prices decline If U S export sales of butter are fairly responsive to changes in U S prices, the U S purchase price for butter may not have to fall much below the international price to balance CCC purchases Currently, butter sells for about 60 cents per pound in international markets or quite a bit above the price at which the model estimates the butter purchase price must

Figure 2
Ratio of milk equivalent purchases of milkfat to nonfat solids



fall to in order to equalize CCC purchases of milkfat and nonfat solids (U S Dept Agr , ERS, 1992a)

The analysis also assumes no new uses for milkfat However, a large decline in the price of milkfat could result in new uses of milkfat or expanded use of milkfat in existing dairy products New uses of milkfat or expanded use of milkfat in dairy products brought on by lower prices could also reduce the drop in the purchase price of butter needed to balance CCC purchases

Summary

In recent years, CCC purchases of dairy products measured on a milkfat basis have greatly exceeded purchases measured on a nonfat solids basis As a result, some product prices have been volatile To help restore stability to product markets, USDA has responded by reducing the CCC purchase price of butter and raising the CCC purchase price of nonfat dry milk USDA's current operating objective is to continue reducing the purchase price of butter and raising the purchase price of nonfat dry milk until CCC purchases of milkfat and nonfat solids are equal on a milk equivalent basis Current legislation states that USDA may adjust CCC purchase prices of butter and nonfat dry milk in order to reduce CCC costs or for other reasons This article derives mathematically the offsetting adjustment in purchase prices that would balance CCC removals of milkfat and nonfat solids on a milk equivalent basis and the offsetting adjustment that would minimize CCC purchase costs This model is used to estimate the offsetting adjustments that would been required to balance CCC purchases and to minimize CCC dairy product purchase costs in 1991

The results indicate that the demand for nonfat milk solids and milkfat are very inelastic under offsetting adjustments in CCC purchase prices This is because the bulk of milkfat and nonfat milk solids are consumed in products that contain both milkfat and nonfat milk solids With the exception of butter and nonfat dry milk, offsetting adjustments in the purchase prices of nonfat solids and milkfat cause little change in the retail prices of dairy products The price elasticity of demand for milkfat and nonfat solids under offsetting adjustments in CCC purchase prices is estimated to be below –0 05 for both milkfat and nonfat solids

Given the large imbalance in CCC purchases of milkfat and nonfat milk solids in 1991, the CCC purchase price of butter would have had to fall to 35-40 cents per pound before purchases of milkfat and nonfat solids would have been equal on a milk equivalent basis The lower CCC purchase price of butter would have increased butter consumption, cutting CCC butter purchases by about 55 percent The offsetting increase in the purchase price of nonfat dry milk would have lowered consumption of nonfat solids and increased CCC purchases of nonfat dry milk by about 45 percent These changes in CCC purchases would have reduced CCC dairy product purchase costs by about $125 million in 1991

Equalizing CCC purchases and minimizing CCC dairy product purchase costs would have led to similar CCC purchase prices and nearly identical dairy program purchase costs in 1991 Thus, adjusting purchase prices with the operating objective of balancing CCC purchase costs appears consistent with the objective of lowering the cost of the dairy program

Dairy program costs were found to be fairly stable over a wide range of purchase prices for butter and nonfat dry milk As long as the purchase price of nonfat dry milk (with appropriate adjustment in the purchase price of butter) fell in the range of $1 05-$1 30 per pound, CCC dairy product purchase costs were near those estimated to minimize CCC purchase costs Over this range in purchase prices, the ratio of milk equivalent purchases of milkfat to nonfat solids varied from 1 73 to 0 13 pounds of milkfat per pound of nonfat solids Thus, there appears to be a considerable range in purchase prices and milk equivalent purchases of milkfat and nonfat solids that yield nearly the same CCC purchase costs as minimizing CCC purchase costs

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