The Effects of Alternate Cow Freshening Distributions on Milk Production and Imports in Florida

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Seasonal swings in milk production in Florida result in a need to import milk on a seasonal basis. A linear programming analysis is used to analyze alternate freshening-date distributions and project the cost savings to Florida dairy farmers from reduced milk imports.

Seasonality in milk production has long been a problem facing the U.S. dairy industry. Uneven monthly supplies of milk raise handlers' operating costs due to the need for excess capacity in trucks, storage facilities, and plant capacity (Kaiser, Oltenacu, and Smith). A uniform production flow would allow more efficient use of facilities and equipment, thereby reducing marketing costs. Florida milk marketing cooperatives, on the other hand, face a seasonal demand and a seasonal supply that are not similar in structure (Table 1). The combination of heat and humidity result in Florida dairy farmers producing less milk in the months of July through November compared to December through June (Table 1). The consequence of this seasonal swing in production is the need to import milk into Florida from other states on a seasonal basis. In 1982, 93.5% of total annual imports entered Florida during the months of July through November (Table 1).

As distance transported and volume of imports increase, Florida dairy cooperatives incur additional costs in fulfilling their contract to deliver milk to processors. A comparison of the average price paid[1] for out-of-state (Florida-produced) milk by Florida cooperatives in 1983 shows that the price in February was $17.48 per hundredweight ($16.90; Florida Department of Agriculture and Consumer Services, "Dairy Summary") and in March it was $17.26 ($16.70) per hundredweight (includes transportation cost to Florida) (Table 1). This milk was from the southeastern United States and predominantly from Georgia. In August, the price was $17.90 ($17.00) and in September it was $18.23 ($16.60) for all milk imported (Florida-produced). This milk was imported from the Southeast and locations outside the Southeast. The average price paid for the milk from the Upper Midwest was $19.36 in August and $19.49 in September (Upper Florida Milk Producers Association).[2]

Reducing seasonal out-of-state milk purchases by Florida milk marketing cooperatives may be accomplished by altering the seasonal nature of Florida milk production. Even without a decrease in overall imports, dampening seasonal imports would decrease the distance imported milk is hauled, saving transportation costs. The objective of this paper is to determine the least-cost levels of Florida milk production handled by Florida cooperatives, fluid milk imports handled by Florida cooperatives, and fluid milk exports handled by Florida cooperatives.

A Model of Milk Procurement for Florida Cooperatives

The heat and humidity in Florida during the late summer and early fall inhibits milk production. A cow greater than 36 months old that freshens in

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[1] All prices in this article are on a delivered-in basis and include an over-order premium if one is negotiated.

[2] When milk is purchased in states north of Florida, the price per hundredweight (not including transportation cost to Florida) is negatively correlated with distance from Florida and is lower than the price of milk produced in Florida; however, the increase in transportation cost generally offsets the reduction in the price of milk.

Table 1. Florida Cooperatives' Milk Demand and Supply for 1983

Month	Demand[a]	Supply: Member Production[a]	Imports[a] Price ($)	Imports[a] Quantity	Exports Penalty Price ($)[b]	Exports Quantity[a]
	----------	----------	Hundredweight	----------	----------	----------
January	1,926,177	1,936,181	—	0	5.30	10,004
February	1,773,571	1,778,014	17.48	2,394	5.41	6,837
March	1,976,003	1,975,907	17.26	6,651	5.43	6,555
April	1,837,751	1,853,675	—	0	5.44	15,924
May	1,837,977	1,863,026	—	0	5.31	25,049
June	1,678,382	1,696,420	—	0	5.35	18,038
July	1,635,932	1,568,005	17.42	69,966	5.41	2,039
August	1,686,615	1,532,489	17.90	155,735	5.50	1,609
September	1,660,749	1,491,117	18.23	173,723	5.53	4,091
October	1,640,191	1,615,156	16.02	35,320	5.39	10,285
November	1,661,318	1,653,847	15.95	27,995	5.31	20,524
December	1,764,632	1,772,410	16.07	23,110	5.78	30,888

[a]Upper Florida Milk Producers Association.
[b]Penalty price equals the Florida price minus the class III price in the Greater Louisiana marketing order minus the transportation cost from Florida to Louisiana of $2.86 per hundredweight.

July, August, or September would produce 12.4%, 12.0%, and 10.3% less milk, respectively, over the lactation period than a cow that freshens in January (DeLorenzo and Maley).[3] Milk produced in July, August, or September is more costly than milk produced in January, in part due to lower production.

Seasonal milk production during a year is directly related to the freshening distribution. Analysis of the seasonal distribution of milk production over 12 months entails analysis of the freshening distribution over 14 months. The freshening distribution in this paper represents those animals freshening in 1983 plus those that did not freshen in 1983 but did produce milk in 1983 (animals freshening in November and December of 1982). Modeling two years is sufficient to capture the inherent dynamic nature of the problem caused by the 14-month lactation and 12-month marketing year. Most Florida cows are culled after 7 months into the third lactation (Dairy Herd Improvement Records), when the farmer may replace the cull cow with a heifer whenever it is to the farmer's advantage to do so. This allows the farmer the flexibility to adjust his herd's freshening distribution.

The year 1983 was chosen for the analysis because it avoids major public-policy changes in the dairy industry, such as the dairy diversion program of 1984 and the dairy herd buyout of 1986–87. The freshening distribution has remained relatively stable across years (Dairy Herd Improvement Records). Thus, seasonal milk production has been relatively stable from one year to the next (Florida Department of Agriculture and Consumer Services, "Dairy Summary"). Thus, 1983 is a good representative year.

The objective function of the model contains total variable production costs for Florida milk plus the cost of importing milk from other states plus the cost of exporting Florida-produced milk. Optimization will find the least-cost combination of (1) Florida production, (2) milk imported and exported from Florida that satisfies the demand constraints, and (3) the freshening constraint boundaries. The model minimizes the cost by Florida cooperatives of providing fluid milk to Florida processors and manufacturers.

Although two consecutive years are analyzed to account for the impact of a 14-month lactation cycle, the cost and milk production accounted for in equation (1) are only those that occurred in 1983. For example, an animal that originally freshens in January 1982 will freshen again in March 1983. This animal will have 2 dry months in 1983 (January and February) from the lactation that started

[3] A similar analysis was not performed on animals in other states; however, a seasonality index based on monthly data was developed on production per cow day for the period January 1977 through December 1981 (U.S. Department of Agriculture). The difference between the maximum and minimum index for Florida was .25 (22.2% of the maximum index). The differences for Minnesota, New York, and Wisconsin are .31 (27.1%), .17 (15.5%), and .24 (21.3%). Furthermore, the minimum indexes (minimum production per cow per day) for Florida, Minnesota, New York, and Wisconsin occur in September, October, November, and November, respectively. Thus, Florida is not unique in having seasonal periods of low productivity; however, the month of lowest productivity does not coincide with Minnesota, New York, or Wisconsin.

in January 1982 and 10 milk months in 1983 from the lactation that started in 1983. This animal will charge 12 months of costs against 1983 and contribute 10 milking months. Thus, the costs minimized in equation (1) are those incurred in 1983.

The mathematical statement of the model is

(1) $$\text{Minimize} \sum_{y=1}^{3}\sum_{s=1}^{3}\sum_{e=1}^{3}\sum_{a=1}^{2}\sum_{m=1}^{12} C_{yseam} X_{yseam} + \sum_{o=1}^{3}\sum_{n=1}^{12} OS_{on} I_{on} + \sum_{n=1}^{12} EX_n FM_n$$

Subject to

(2) $$\sum_{y=2}^{3}\sum_{s=1}^{3}\sum_{e=1}^{3}\sum_{a=1}^{2}\sum_{m=1}^{12} P_{yseamn} X_{yseamn} - T_n = 0 \qquad n = 1, \ldots, 12$$

(3) $$\sum_{m=1}^{12} X_{2seam} + \sum_{m=11}^{12} X_{1seam} = X_{2sea} \qquad s = 1, 2, 3;\ e = 1, 2, 3;\ a = 1, 2$$

(4) $$LBX_{2seam} \leq X_{2seam} \leq UBX_{2seam} \qquad s = 1, 2, 3;\ e = 1, 2, 3;\ a = 1, 2;\ m = 1, \ldots, 12$$

(5) $$\sum_{m=1}^{12} X_{3seam} + \sum_{m=11}^{12} X_{2seam} = X_{3sea} \qquad s = 1, 2, 3;\ e = 1, 2, 3;\ a = 1, 2$$

(6) $$LBX_{3seam} \leq X_{3seam} \leq UBX_{3seam} \qquad s = 1, 2, 3;\ e = 1, 2, 3;\ a = 1, 2;\ m = 1, \ldots, 12$$

(7) $$T_n + \sum_{o=1}^{3} I_{on} - FM_n = QF_n \qquad n = 1, \ldots, 12$$

(8) $$I_{on} \leq AI_{on} \qquad n = 1, \ldots, 12;\ o = 1, \ldots, 3$$

(9) $$FM_n \leq AE_n \qquad n = 1, \ldots, 12$$

$$X_{yseam}, I_{on}, FM_n, T_n \geq 0$$

where y is year (1 for 1981, 2 for 1982, 3 for 1983);

s is herd size (1 for under 500 cows, 2 for 500 to 1000, and 3 for over 1000);

e denotes management efficiency class (1 for excellent, 2 for average, and 3 for below average);

a denotes animal type (1 is a heifer less than 36 months old, and 2 is a cow greater than 36 months old);

m is month of freshening;

C_{yseam} is the total variable production cost incurred in 1983 for a dairy animal type a from herd size s and management efficiency class e freshening in month m of year y;

X_{yseam} is the number of dairy animals of type a from herd size s and management efficiency class e freshening in month m of year y;

o is origin of out-of-state milk (1 is the most distant and 3 is the nearest region);

n is the month in which milk is produced, exported, or imported for calendar months January to December (1 to 12) in 1983;

OS_{on} is the cost of milk imported from origin o in month n;

I_{on} is the cost of milk imported from origin o in month n;

EX_n is the Florida penalty cost in dollars per hundredweight for milk exported from Florida in month n;

FM_n is the amount of Florida milk exported in month n;

P_{yseamn} is the production in the nth month in 1983 for a dairy animal of type a from herd size s and management efficiency class e freshening in month m in year y;

T_n is the transfer mechanism that balances monthly Florida production, imports, and exports in month n of 1983 with cooperative need for milk;

X_{2sea} is the number of dairy animals of type a from herd size s and management efficiency class e in 1982;

LBX_{yseam} is the lower bound for the number of dairy animals type a in size class s and management efficiency class e freshening in month m and year y;

UBX_{yseam} is the upper bound for the number of dairy animals of type a in size class s and management efficiency class e freshening in month m and year y;

QF_n is the quantity of milk supplied by Florida cooperatives to the Florida market in month n;

AI_{on} is the available amount of imports from source o in month n; and

AE_n is the available amount of exports in month n.

The optimal solution to the model represents the least-cost monthly combination of Florida production and cooperative out-of-state fluid milk purchases (imports) and fluid milk sales (exports) that satisfies the demand requirements of the Florida market. Milk production in any month (n) is determined by the number of cows and heifers freshening in any month (m) and producing in the nth month of 1983 (equation 2). The number of cows and heifers is controlled for both years' freshening herds (equations 3 and 5).[4] The number of heifers and cows freshening in any month (m) is limited by the upper and lower bounds of the flexibility inequalities (equations 4 and 6). This range is based on the degree of relaxation applied to the original freshening-date distribution. The least-cost solution for all production months is subject to the contractual supply obligations (QF) of the Florida cooperatives (equation 7). The quality of milk imported and exported is constrained (equations 8 and 9).

In the model, the freshening distribution of cows is assumed to be more rigid in structure than heifers. This is due to the biological constraints for breeding that become more restrictive as the cow ages. The freshening distribution of heifers is assumed more flexible because managers have control over the freshening pattern of heifers through replacement purchases. The current freshening distributions are the result of biological constraints, management practices concerning breeding, conception rates, culling, replacements, and traditional dairy practices. These considerations form the constraints incorporated in the model to restrict the amount of change that can occur in the freshening distribution (inequalities 4 and 6).

An analysis of changes in Florida production costs due to the change in the freshening distributions will quantitatively determine the lower bound of the incentive price (i.e., the producer price that will stimulate additional production). The incentive price must be at least as large as the production cost. Changes in production costs for Florida producers due to a shift in the freshening distribution are measured by comparing the cost of production among freshening distributions. The freshening distribution is altered by varying the constraints on freshening (inequalities 4 and 6) to reflect estimated managerial behavior. The upper bound of the incentive price range is the savings gained from reduced imports plus the Florida price. The savings gained from reduced imports could be paid to

[4] The number of animals freshening in November and December of 1982 (the last 2 months of the 14-month cycle of animals producing milk in 1982) must equal the number of animals freshening in November and December of 1982 (the first 2 months of the 14-month cycle that includes animals producing milk in 1983). This links the 2 months together.

Florida producers only on the increased production that replaces imports.

Data

The distribution of Florida herd sizes was determined by an analysis of the 1982 farm census (U.S. Department of Commerce, Bureau of the Census), Florida Department of Agriculture and Consumer Services "Dairy Summary," and commercial Florida dairy permit records from the Division of Dairy Industry (Florida Department of Agriculture and Consumer Services, Division of Dairy Industry). This information allows for a county-by-county estimate of the number of Florida dairy farms and herd sizes. Those Florida counties in milk marketing orders 6, 12, and 13 (98.6% of the Florida herd) are used in this analysis (Florida Department of Agriculture and Consumer Services, "Dairy Summary"). Herd size categories used are under 500 head, 500 to 1,000 head, and over 1,000 head. The total number of Florida commercial dairies in 1983 was 379 and the Florida herd size was 184,800 head for the counties included in the analysis. The number of cows in herds under 500 head is 54,784 cows, 500 to 1000 head is 59,956 cows, and over 1000 head is 70,060 cows.

The structure of the Florida dairy herd is condensed to nine categories. Herd size (three size ranges) is combined with three management efficiency categories. The three levels of management efficiency are excellent, average, and below average. Herd size/management efficiency percentages were established in consultation with the Dairy Science Department at the University of Florida. The excellent efficiency class contains 33% of the animals in the under 500 head herd size category, 30% of the animals in the 500 to 1,000 head herd size category, and 45% of the animals in the over 1,000 head herd size category. The average efficiency class receives 34% of the animals in the under 500 head herd size category, 50% of the animals in the 500 to 1,000 head herd size category, and 45% of the animals in the over 1,000 head herd size category. The below-average efficiency class receives 33% of the animals in the under 500 head herd size category, 20% of the animals in the 500 to 1,000 head herd size category, and 10% of the animals in the over 1,000 head herd size category.

Feed costs are affected by herd size and quality of management. The production costs used in this article are based on Giesy. A manager can affect feed prices by purchasing feed in large quantities and controlling storage, mixing, and handling functions. Feed costs are also affected by management's ability in balancing rations and grouping cows. With the Florida herd structurally divided into three size categories, it is assumed that the under 500 head herds have no reduction in feed cost, that the 500 to 1,000 head herds receive a 20% reduction in feed costs, and that the herds over 1,000 head have a 25% reduction in feed cost (Giesy, p. 25; Dairy Herd Improvement Records). Below-average managers have 10% higher feed costs than average managers, and excellent managers have 10% lower feed costs than average managers.

All other variable costs are taken from Giesy. Certain costs are influenced by herd size and quality of management (*HSQM*), others by quality of management only (*QM*), and others do not vary among farms. These costs are replacements (*QM*), labor (*HSQM*), employment tax (*HSQM*), pasture management (*QM*), utilities (*QM*), veterinarian and drugs (*QM*), supplies (*QM*), fuel (*QM*), breeding (*QM*), Dairy Herd Improvement fees, hauling and dues, legal and accounting costs, miscellaneous cost, interest on debt, and insurance and taxes.

Each herd size/management efficiency category is composed of two subcategories, heifers less than 36 months of age and cows greater than 36 months of age. The distribution of animals across age and months of freshening is determined from data provided by the Dairy Science Department at the University of Florida.

A lactation curve is constructed through an analysis of lactation records. The lactation curves are polynomial equations derived from Florida Dairy Herd Improvement Association lactation records (Delorenzo and Maley). An equation for each month of the year was derived for first lactation heifers (i.e., heifers less than 36 months old) and for cows with more than one lactation (i.e., greater than 36 months old), resulting in 24 lactation equations. The lactation curves provide daily milk production, and the summation of the dairy production provides monthly production per animal. The lactation cycle for all freshening dates is 11 months of milk production plus 3 months of no production (Funk, Freeman, and Berger).

The monthly quantity of milk supplied to the Florida market by Florida cooperatives is fixed (Upper Florida Milk Producers Association). Three regional sources of out-of-state milk from which cooperatives may purchase milk are considered, and the amount of milk available from these sources in any month is fixed. These sources are aggregated into three areas. The first area is within an arc 500 miles from Florida, the second area is between arcs 500 and 1,000 miles from Florida, and the last area is between arcs 1,000 and 1,500 miles from Florida.

Florida producers have excess milk when production exceeds the quantity demanded by contracted handlers. The excess milk is used either in Florida non-pool plants as Class II milk (milk used in soft dairy products such as ice cream) or shipped to other states for disposal. The milk shipped to other states is called exported milk. Exported milk is disposed of using the Greater Louisiana milk order at the Class III price (milk used in hard cheese, nonfat dry milk, and butter) less transportation. The Louisiana disposal site was chosen because of the quantity of cheese manufacturing plants located in the region. The penalty price is the difference between the return on exports and the average Florida price which results in a loss to Florida dairymen. The transportation cost to Louisiana is estimated to be $2.86 per hundredweight based on an equation by Schiek.

Empirical Scenarios

The Base0 model approximates the conditions found in Florida in 1983 (equations 2 through 9). When *LBX* equals *UBX* in equations (4) and (6), the model constrains the number of dairy animals X_{yseam} to the 1983 Florida freshening-date distribution. To evaluate the economic feasibility of altering the seasonal production of milk in Florida, the 1983 freshening distribution is allowed to change in the Flex models 1, 2, and 3 (Table 2). Florida imports and exports are allowed to change using a less-than inequality (equations 8 and 9).

The first degree of flexibility (Flex1) allows each X_{yseam} to change from the 1982 and 1983 value by a maximum of plus or minus 10%. The second degree of flexibility (Flex2) assumes different percentage changes for heifers and cows. The flexibility for all cows (X_{yseCm}) is still 10%, but the flexibility of heifers (X_{yseHm}) is increased to 20%. This reflects the ability of managers to influence their freshening distribution through replacement purchases and the lower level of breeding constraints associated with heifers. The third degree of flexibility (Flex3) allows the amount of change to vary according to the year of freshening. This third flexibility condition reflects a temporal approach in the ability of managers to influence their herd distributions given a specific objective. The 1982 freshening cows (X_{2seCm}) and heifers (X_{2seHm}) retain the degree of flexibility as outlined for Flex2. However, the 1983 freshening cows (X_{3seCm}) are allowed to change by a maximum of 20%, and the 1983 heifers (X_{3seHm}) are allowed to change by a maximum of 30%. The greater range for 1983 freshening as compared to the 1982 freshening models the annual short-term adjustments that producers may adopt in response to incentives from their cooperatives.

Empirical Results

Florida production, Florida cooperative imports of milk into Florida, Florida cooperative exports from Florida, total (average) cost per hundredweight of milk demanded in Florida from Florida cooperatives, total (average) cost per hundredweight of Florida produced milk, and total (average) cost of milk imported by Florida cooperatives are reported in Table 2. The Base0 and Flex models have quantity demanded fixed at the 1983 level. The Base0 model has imports and exports fixed at 1983 levels, whereas the Flex models have imports and exports equal to or less than 1983 levels. As the constraints on the freshening-date distribution are relaxed from Base0 to Flex3, average total cost, average production cost, and average import cost

Table 2. Florida Results for 1983

	Production	Imports	Exports	Total Cost (Average)	Production Cost (Average)	Import Cost (Average)
	Hundredweight			*Dollars*		
Base0	20,736,247	494,894	151,843	275,786,900 (13.08)	266,245,430 (12.84)	8,714,114 (17.61)
Flex1	20,794,121	285,177	-0-	268,968,800 (12.76)	264,047,212 (12.70)	4,921,588 (17.26)
Flex2	20,806,217	273,081	-0-	267,446,700 (12.69)	262,783,033 (12.63)	4,663,667 (17.08)
Flex3	20,928,833	150,465	-0-	265,631,900 (12.60)	263,120,635 (12.57)	2,511,265 (16.69)

decline by 3.67%, 2.10%, and 5.22%, respectively (Table 2). Florida production increased by 0.93%, and quantity imported and exported decreased by 69.60% and 100%. The number of months with imports drops from eight to six (Table 3). When Flex3 is compared to Base0, the percentage of animals freshening from November through December in 1982 is greater in Flex3 and the freshenings from January through May are lower in Flex3 (Figure 1). The increase in animals freshening in November and December provides the milk lost by the drop in freshenings in January through May. The percentage of animals freshening from June through August is higher in Flex3 and these animals provide the milk lost by the drop in freshenings from September through October (Figure 1). This adjustment in the freshening distribution results in a reduction in imports, exports, average total cost, and average production cost.

The reduction in production cost is an interesting finding. Conventional wisdom suggests that changing the freshening distribution would increase production cost and decrease marketing costs. In fact, both decreased. Even though the economic incentive (i.e., the reduction of production costs) exists, farmers may not take advantage of the incentive because of the feeling among farmers that it is difficult to produce milk during the high temperature and high humidity months. Milk production per cow drops and conception rates decrease. Even though the cost savings may be present, the savings is not enough to convince the farmer to alter the seasonal production of milk.

As additional flexibility in the freshening-date distribution is allowed in the model, total cost declines (Table 2). Total cost is Florida production cost plus import cost plus an export penalty. Since the quantity demanded in Florida is fixed, a reduction in total cost represents a decline in average cost (Table 2). These savings are caused by shifting from expensive distant imports to increased Florida production. For example, the change from a fixed freshening-date distribution in Base0 to a change of plus or minus 10% in the freshening-date distribution of both heifers and cows in Flex1 results in $6.82 million savings (2.47% of the total cost in Base0). The largest total cost savings of $10.16 million (3.68% of Base0) is attained from allowing the highest degree of flexibility (between Base0 and Flex3).

Table 3. Predicted Monthly Imports into Florida from Base0 and Flex Models

	Base0	Flex1	Flex2	Flex3
	Hundredweight			
January	0	0	0	0
February	2,394	0	821	0
March	6,651	4,943	5,985	1,413
April	0	0	0	0
May	0	0	0	0
June	0	0	0	0
July	69,966	45,440	39,334	7,143
August	155,735	101,898	86,028	34,954
September	173,723	116,098	104,708	79,188
October	35,320	0	0	0
November	27,995	4,241	13,096	4,657
December	23,110	12,557	23,110	23,110

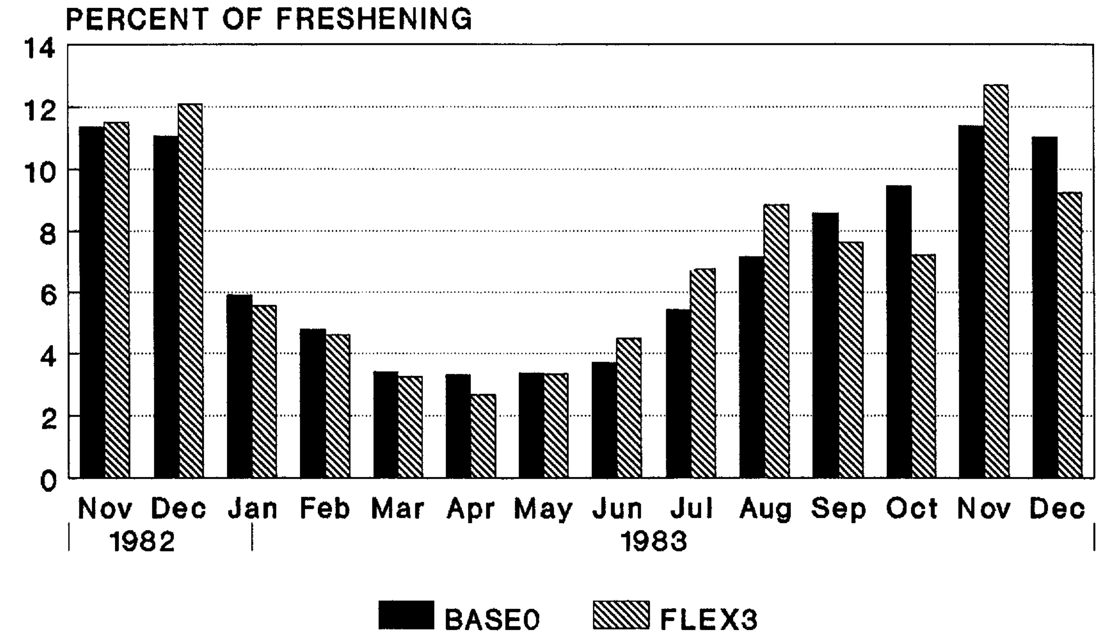
Increasing the freshening-date flexibility decreases Florida production costs from $12.84 per hundredweight to $12.57 per hundredweight, or a 2.10% decrease (Table 2). Approximately 50% of the reduction in production costs occurs between Base0 and Flex1. The remaining reduction occurs as the freshening-date distribution is allowed to be more flexible.

Every decrease in the quantity of imports is accompanied by increased Florida production (Table 2). The greatest change occurs between Base0 and Flex3. Imports drop 344,429 hundredweight (69.60% of 1983 imports) and production increases by 192,586 hundredweight (0.93% of 1983 production). Florida production increased, but not by the same amount as imports decreased because exports decreased. The reduction in imports decreased total import expenditures by $6.2 million (71.18%). This reduction in imports represents $0.29 per hundredweight of milk demanded in Florida from Florida cooperatives, or $0.023 per gallon.

In the least restricted model (Flex3), Florida remains a net importer of milk. In late summer, Florida exhausts the supply available from nearby regions and must pay larger transportation charges to import from distant regions. Supply region three delivers milk to Florida during eight months (in Base0) at the lowest cost. Regions two and one deliver milk during the late summer and early fall months at progressively higher prices. As the models become less restrictive, imports are decreased, beginning with the most expensive regions.

Conclusions

Florida milk producers can alter the freshening-date distribution of cows and heifers and decrease the importation of milk. This could reduce Florida production costs by as much as $0.27 per hundredweight (2.1%) and the average cost of imports by as much as $0.92 per hundredweight (Table 2). The needed change in milk production is marginal in that 1983 imports represent only 2.4% of annual



BASE0 : FLORIDA DHIA 1983 RECORDS
FLEX3 : MODEL RESULTS

Figure 1. Florida Dairy Cow Freshening Distribution

Florida production. However, Florida farmers need an incentive to produce milk during the high temperature and high humidity months. Even though the economic incentive (i.e., the reduction of production costs) may exist, farmers may not take advantage of the incentive because of the feeling among farmers that it is difficult to produce milk during the high temperature and humidity months. Milk production per cow drops and conception rates decrease. Even though cost savings may be present, the savings may not be adequate to alter the seasonal production of milk.

Given that the average price in Florida during 1983 was $16.50 per hundredweight and the average cost of the imports that were replaced in the modeling (replaced imports equaling the difference between Base0 and Flex3) is $18.01 per hundredweight, a price premium of $1.51 per hundredweight can be offered to farmers to stimulate additional production during the import months of the year. This incentive may change by month depending on the quantity of milk needed. The mechanism used to distribute the incentive could be a season pricing plan operated by the milk marketing cooperative.

Florida milk marketing cooperatives may have difficulty negotiating over-order premiums. Over-order premiums are justified in part by the need to import milk that costs more than Florida-produced milk. With a decrease in imports, cooperatives need to inform processors of the seasonal pricing plan and that Florida-produced milk is substituted for imports. The premium paid to obtain Florida-produced milk is paid to Florida producers, instead of the producers of imported milk. To discontinue the premium to Florida producers would likely result in decreased Florida production and increased imports because Florida farmers would lose the incentive to produce additional milk.

Cooperatives could also encourage farmers, through extension programs, to adopt methods of cooling animals during the summer. Research on cooling has been done at the University of Florida and the methods have been adopted by some farmers and been found useful.

Florida will remain an importer of milk from regions close to Florida. Milk can be imported from these regions at a cost not that different from the Florida price. Further research is needed on the price and revenue sides that were not explored in this article. The supply response to a price incentive is not known and is beyond the scope of this study.

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